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International Genetic Engineering Campaign

Background Information **April 2002**

Maize Under Threat

Mexico, center of diversity for maize, has been contaminated

In September 2001 the Mexican government, by means of its Intersecretarial Commission for Biosecurity and Genetically Modified Organisms (CIBIOGEM), announced that scientists discovered contamination of indigenous varieties of maize with genetically engineered (GE) varieties imported from the United States. The contamination was found in the state of Oaxaca in Mexico – one of the world's centres of origin and diversity of maize.

Research showed that 15 of 22 communities where maize seeds were tested this year were found to have been contaminated by GE maize and that 3 percent to 10 percent of the maize seed tested contain genes from GE maize. Two communities showed even higher rates of contamination. Clearly many traditional maizefields in the region have been contaminated; regulators do not yet know the extent of the contamination.

The magnitude of the problem in Oaxaca is large. To put the contamination rates in perspective consider a few statistics regarding maize and maize pollen. Emberlin et al (1999) estimate that a typical maize field has 50,000 plants per hectare. A 1 percent contamination rate means 500 plants per hectare contain the transgene. Maize sheds large amounts of pollen – about 175 kilograms per hectare – or between 14 and 50 million pollen grains per plant. While most maize pollen will fall within 500 meters of the crop field, transport of pollen over longer distances is possible. Bees can disperse pollen up to several miles; under unusual weather conditions, wind may carry pollen up to hundreds of kilometers. The potential for contamination of neighboring fields is a serious reality.

Maize and its close relatives are found throughout Latin America

Teosintes, the closest wild relatives of cultivated maize, are found growing from Chihuahua to Oaxaca. In addition to teosintes, a large store of maize diversity exists in the multitude of landraces – local cultivated varieties – grown throughout Mexico and other maize growing countries in Central and South America.[1] In Mexico, the thousands of landraces of maize are called *criollo* maize.

The many varieties have different growing characteristics suited for changing climate conditions. In Chihuahua, Mexico, the fast growing variety Apachito is planted when the rains are delayed. Coloured varieties correlate with varying maturation periods. Blue and red pigments in maizestalks help maize varieties warm up quickly on cool mornings. This makes them especially suitable to be planted earlier in the year. A fast maturing variety in Colombia was given the name *matahambre*, which translates as 'hunger killer'.

[1] Other centres of maize diversity include lowland Central America, highland Guatemala, the central Andes, the northern edge of South American and the Caribbean, and the Amazon basin. (Goodman, 1976)

Why care about crop genetic diversity?

Our crop plants were domesticated thousands of years ago from wild ancestors. Those ancestors have continued to persist in regions where domestication took place, and still contain genes important for agricultural production. Because crop plants may still interbreed with many of their wild relatives, genes from the wild can be used to improve our crop plants. Genetic information for important characteristics such as disease and pest resistance, yield and flour quality are continually sought and utilized in breeding programs of all of our major crop plants. A diverse repository of genes is essential to breeders around the world as they work to adapt crops to new pests and diseases and to changing climatic conditions. *The genetic diversity of crops such as maize is directly related to food security.*

Jack Harlan, the famous botanist, has noted that genetic diversity "stands between us and catastrophic starvation on a scale we cannot imagine." Loss of genetic diversity is epidemic worldwide; it is termed genetic erosion. According to the UN Food and Agriculture Organization (FAO), 75% of our crop genetic diversity has been lost within the last one hundred years.

Because of the continued need of modern breeding programs for new characteristics and genes, crop genetic conservationists concern themselves with preserving wild relatives of crop plants, as well as those local varieties of crops that small-scale agriculturalists grow in the many diverse cropping system habitats found throughout the world. Often these wild relatives and landraces, as local varieties are often called, are found in small populations, making conservation difficult.

Crop diversity is essential to the future of our agricultural systems. But it is also an essential component of our cultures. Consider the many varieties of potatoes grown by peoples living in the Andes, or the wide variety of eggplants, squashes and gourds used throughout Asia. Preservation of crop diversity is also a means of preserving elements of cultural diversity.

Maize under threat

As noted above, genetic diversity is critical to the continuing development of varieties resistant to new pests, diseases, and changing climatic and environmental conditions. Diversity is important for global food supply and food security. The lack of genetic diversity, conversely, can be linked to many of the major crop epidemics in human history. For example, in 1970, the maize crop in the southern United States was attacked by a disease called Southern maize leaf blight. Because of genetic uniformity among the maize varieties grown across the US, the loss to this disease was great – in total the US lost 15% of its harvest – at the time worth around $1 billion. Loss of genetic diversity due to loss of cultivated varieties – genetic erosion – is happening in maize as well as in all our other major and minor crop plants. According to Genetic Resources Action International "only 20 percent of local maize varieties reported in Mexico in 1930 are still known."

Currently maize resources are under threat in two primary ways: the displacement of local varieties and the contamination of teosinte by hybrid maizes. These threats are likely to increase in magnitude with genetically engineered maize.

Ellstrand (2001) and others (Ellstrand et al. 1999; Linder et al. 1998; Snow et al. 1999, 2001) have written extensively from the perspective of evolutionary biology on the threats that genetically engineered crops may pose to landraces and wild relatives. Some of their general conclusions about genetic contamination include:

- If there is no further inflow of contaminating gene, the nature of the trait conferred by that gene will significantly influence whether the gene disappears, remains at low frequencies, or increases in frequency. (Ellstrand 2001; Ellstrand et al. 1999)

- Evolutionary theory predicts that a beneficial gene will increase in frequency, as natural selection or farmer selection differentially favors individuals carrying that gene. For example, if the gene codes for insect resistance, such as a *Bt* gene, we would expect it to confer a benefit and to increase in frequency in the population. This could result in a decrease in frequency of other genotypes and a concomitant loss of genetic diversity. (Ellstrand 2001; Ellstrand et al. 1999)

- If the gene is neutral in effect, evolutionary theory predicts that the gene will persist at a low frequency. It is a misconception that only beneficial genes will persist in a population. (Ellstrand 2001; Ellstrand et al. 1999)

- Even crop genes that reduce the fitness of a crop-weed hybrid have been shown to be maintained in weed populations over time. (Snow et al. 1999; Snow et al. 2001) Many scientists had assumed that transgenes were inherently problematic for a plant and would always eventually be lost. Experimental evidence shows that this is not the case.

- If a deleterious gene is eventually lost, there is a concomitant loss of genetic diversity as that population carrying the gene will also be lost. Even the eventual loss of a transgene can have a negative impact on the conservation of maize diversity. Transgenes don't just disappear by themselves – they take the transgenic individuals and the diversity they contain with them.

- It is impossible to predict future frequencies of contaminating genes without having identified the source of the contamination and without assurance that gene flow has been halted. If in fact there is no halt to the gene flow, we would expect continuing contamination and potential loss of diversity through swamping. (Linder et al. 1998)

Consequences of transgene contamination for wild relatives of maize – the teosintes

Because crop plants and their wild relatives are closely related evolutionarily, they are often able to interbreed, to greater or lesser degrees. This means that there is the potential for genetically engineered crops to hybridize with wild relatives and for the offspring to be viable. Most scientists agree that teosintes and cultivated maize interbreed. The offspring of a maize-teosinte cross may be more or less successful than the wild parent; either result could have negative long-term consequences for diversity conservation.

As noted above in the general remarks about genetic contamination, one problematic result of a maize-teosinte cross would be if the crop-wild relative hybrids were more successful in some way. Certainly crops engineered to be tolerant to pests and their offspring would have an advantage over wild relatives that had no such novel gene. Scientists have raised the concern that such hybrids could become problem weeds, creating a nuisance for farmers and also outcompeting the wild relatives in the non-agricultural environment.

A second concern raised by scientists is the potential for crop-to-wild gene flow to lead to the extinction of rare species. This extinction can happen in two ways – through processes known as swamping and outbreeding depression. In swamping, the population of wild plants is continually exposed to the crop, and hybrids are continually forming. If the hybrids are viable and continue to mate with the wild relative, eventually the genetic integrity of the wild relative is swamped by the continual influx of genes from the cultivated plant. Small populations and rare species can be lost. The second process is known as outbreeding depression, where there is detrimental gene flow, resulting in offspring that are less fit. Eventually the population disappears. According to Ellstrand et al. (1999), "both phenomena can lead to extinction rapidly." Most of the small populations of wild teosintes are already under serious threat. Contamination from an escaped transgene could push them over the edge.

GE maize poses broader ecological threats as well

The contaminating gene found in Mexican landraces is a form of the Bt gene, which produces a pesticide toxic to many species of lepidopteran insects. There has been a huge controversy in the United States and other countries over the use of Bt genes primarily because of the potential ecological impacts associated with plants producing the pesticide. These impacts include harm to non-target organisms, including species such as the monarch butterfly and the green lacewing, a beneficial predatory insect; and impacts on soil biota through exudates of Bt from maize roots.[2]

The diverse ecological risks associated with Bt maize are troubling if one considers that contamination of maize landraces could be long-lasting. As noted above, the gene will almost certainly confer benefit to the landraces it contaminates; farmers and natural selection forces will help to maintain populations containing the gene. If the gene becomes widespread in landrace populations, as it appears to be currently, the ecological impacts will be impossible to prevent or mitigate.

Food Dictators

The transnational corporations (TNCs) that produce GE maize are the same companies that dominate seed and pesticide production and genetic engineering. These agrochemical companies behave like *food dictators* and force-feed Genetically Modified Organisms (GMOs) to farmers and consumers while dictating the future of food and agriculture.

Genetic engineering is a proprietary technology monopolised by a very small number of TNCs. Most of the seed and pesticide market is already in the hands of just three giants: Monsanto (Pharmacia group), Syngenta (formerly Novartis) and Aventis (created by Hoechst and Rhône-Poulenc). In 2000, Monsanto products alone accounted for 91 percent of the total area sown to GMOs.

These food dictators increasingly deny farmers their ancient right to save, exchange and replant seed, because GE seeds are patented and cannot be replanted. These companies bring to court even those who infringe their patents on crops involuntarily. These food dictators also spread GE crops and genetic contamination while using GE seeds to undermine sustainable agriculture. Meanwhile, our food supply is becoming increasingly dependent on a technology that is potentially damaging to the environment and could pose health risks.

Finally, these food dictators damage biodiversity, including centres of diversity and origin, such as Mexico, on which the future of food production and agriculture depends. But they also refuse to take responsibility for the problems they are causing. That’s why Greenpeace demands strong regulations on corporate liability.

[2] See Obrycki et al. (2001) for a thorough review of ecological concerns. Their review of the ecological risks led the authors to the conclusion that benefits associated with use of Bt maize may not outweigh the potential ecological and economic risks.

Greenpeace demands:

- No irreversible releases of Genetically Engineered Organisms into the environment
- No releases of Genetically Engineered plants in their centres of diversity
- No import of Genetically Engineered food commodities into their centres of diversity

Greenpeace believes this contamination underscores the need for the immediate ratification of the Cartagena Biosafety Protocol by its signatories.

Further, we strongly urge the Mexican government to develop and implement an emergency plan that should include the following steps:

- Undertake immediately a rapid assessment of the scope and magnitude of the contamination in Mexico and the GE varieties involved.
- Determine the source of the contamination.
- Declare an immediate halt to the importation of GE maize.
- Develop and implement immediately a de-contamination plan.
- Establish quickly national legislation and regulations to guarantee that this contamination will not occur again.
- Investigate the legal responsibilities of the governmental authorities that allowed the contamination to take place.
- File legal action on behalf of the affected communities against the companies responsible for production and dissemination of GE maize.
- Inform immediately the signatory countries to the Cartagena Protocol, in particular those countries that are centres of origin and diversity of maize that could be facing the same risk.

AFTER THE CONTAMINATION WAS DISCOVERED…

- **Sep. 2001:** Greenpeace, along with 40 Mexican groups, proposes an emergency plan which calls for the Mexican government to stop importing GE maize into Mexico and other emergency steps to be taken.
- **Nov. 2001:** More than 90 scientists and plant breeders issue a call to all governments to protect the genetic resources of corn and its relatives.
- **Nov. 2001:** Peer-reviewed article documents contamination: sequences of GE corn present in landraces of corn from Oaxaca region in Mexico.
- **Dec. 2001:** Mexican scientists present their findings of contamination to an OECD scientific conference.
- **Jan. 2002:** Information from a government source indicates higher levels of contamination than originally feared - up to 20-60% in four communities tested.
- **Apr. 2002:** Up to now, nothing has been done to stop GE corn imports (the most likely source of this pollution), let alone to take legal action against those to blame for the contamination.

Further Reading:

Centres of Diversity: global heritage of crop varieties threatened by genetic pollution.
Available from: www.greenpeace.org/~geneng/reports/gmo/CoDpdf.pdf

References and related articles:

Ellstrand, N.C. 2001. When transgenes wander, should we worry? *Plant Physiology* 125: 1543-1545.

Ellstrand, N.C., H.C. Prentice, and J.F. Hancock. 1999. Gene flow and introgression from domesticated plants into their wild relatives. *Annual Review of Ecology and Systematics* 30: 539-563.

Emberlin, J., B. Adams-Groom, and J. Tidmarsh. 1999. A report on the dispersal of maize pollen, commissioned by the Soil Association. Worcester, UK: National Pollen Research Unit.

Genetic Resources Action International. 1996. The biotech battle over the golden crop. *Seedling* 13(3): 23-32.

Goodman, M.M. 1976. Maize. In Simmonds, N.W. (ed.), Evolution of Crop Plants. Essex, UK: Longman Scientific & Technical.

Hall, L., K. Topinka, J. Huffman, L. Davis, and A. Good. 2000. Pollen flow between herbicide-resistant *Brassica napus* is the cause of multiple resistant *B. napus* volunteers. *Weed Science* 48(6): 688-694.

Linder, C.R., I. Taha, G.J. Seiler, A.A. Snow, and L.H. Riesberg. 1998. Long-term introgression of crop genes into wild sunflower populations. *Theoretical and Applied Genetics* 96: 339-347.

Mikkelsen, T.R., B. Andersen, and R.B. Jorgensen. 1996. The risk of crop transgene spread. *Nature* 380: 31.

Nigh, R., C. Benbrook, S. Brush, L. Garcia-Barrios, R. Ortega-Paczka, and H.R. Perales. 2000. Transgenic crops: A cautionary tale. *Science* 287 (5460): 1927.

Obrycki, J.J., J.E. Losey, O.R. Taylor, and L.C.H. Jesse. 2001. Transgenic insecticidal corn: Beyond insecticidal toxicity to ecological complexity. *BioScience* 51(5): 353-361.

Serratos, J.A., M.C. Willcox, and F. Castillo (eds.). 1997. Gene flow among maize landraces, improved maize varieties, and teosinte: Implications for transgenic maize. Mexico, D.F.: CIMMYT.

Snow, A.A., B. Andersen, and R.B. Jorgensen. 1999. Costs of transgenic herbicide resistance introgressed from *Brassica napus* into weedy *B. rapa*. *Molecular Ecology* 8: 605-615.

Snow, A.A., K.L. Uthus, and T.M. Culley. 2001. Fitness of hybrids between weedy and cultivated radish: Implications for weed evolution. *Ecological Applications* 11(3): 934-943.