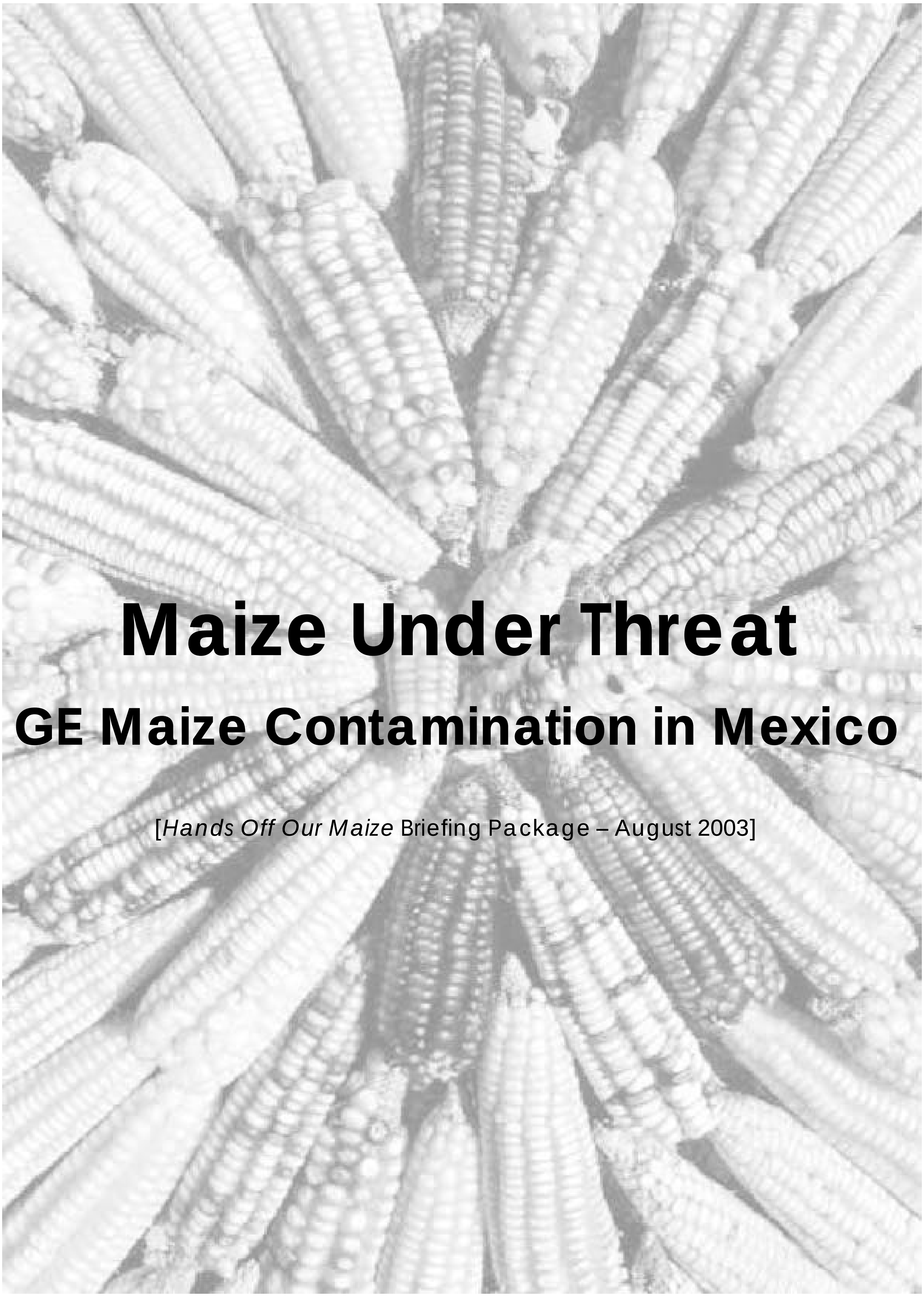

# Maize Under Threat

## GE Maize Contamination in Mexico

[*Hands Off Our Maize* Briefing Package – August 2003]

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# 1 BACKGROUND & OVERVIEW

## 1.1 HISTORY OF MAIZE CONTAMINATION

In January 1999, Greenpeace warned the Mexican government that since adequate controls were not in place to keep traditional maize separate from genetically engineered (GE) maize, contamination was inevitable.

Greenpeace made it clear that the contamination of traditional maize varieties with transgenic maize varieties would create far-reaching negative impacts. These included serious damage to biological diversity, reduction in the effectiveness of natural pest control, unknown long term effects to fauna and flora and increased socio-economic hardship for a majority of Mexican farmers. The Mexican maize case also posed the first transgenic contamination threat in a centre of crop diversity – important regions for the development of new breeds or varieties of crops.

Greenpeace gave the Mexican government evidence on 25 May 1999 that maize imported from the United States contained transgenic seeds. In response, on 2 June 1999, the Mexican government stated publicly that, given the risk posed to native maize varieties, it had established a moratorium on transgenic maize seed for experimental purposes. But the government continued to allow the import of huge quantities of GE contaminated maize from the USA, although the government must have been aware that this imported grain could be used as seed. Traditional farmers see no differences between grain for seed and food purposes, and often plant small amounts of available grains to see whether they carry interesting traits for breeding.

By September 2001 it was clear that the genie was already out of the bottle when Mexican government officials reported that scientists had discovered contamination of indigenous varieties of maize with genetically engineered (GE) varieties. The contamination was found in the state of Oaxaca. In 2001, the Mexican Ministry of the Environment and Natural Resources (Semarnat) confirmed that *"a sample taken from the warehouses of Diconsa (a state company which distributes basic consumer products to remote and poor rural communities) in the town of Ixtlán de Juárez showed that approximately one-third of the grain was contaminated."*

Further proof of contamination came on 29 November 2001 when the journal, *Nature*, published research by David Quist and Dr. Ignacio Chapela providing detailed scientific information on the contamination of native maizes by transgenic maize genes (transgenes) in Oaxaca. Dr. Chapela, a professor at the University of California at Berkeley confirmed: *"I must stress that the Oaxaca case is simply the one which, for various reasons, I decided to analyse and is not necessarily an isolated case. This contamination may be much more widespread and, what would be even more serious, may affect the wild relatives of the maize. The matter merits emergency measures starting with those aimed at eliminating all sources of genetic contamination of the maize".*[1]

In January 2002 the Mexican government further reported that 15 of 22 communities where maize seeds were tested were found to have been contaminated by GE maize. In eleven of the communities, contamination levels were between 3% and 13% and in four localities levels of contamination found were much higher – between 20% and 60%. In the Mexican government food distribution agency stores (DICONSA), 37% of the grain was found to be transgenic. Clearly many traditional maize fields in the region have been contaminated; regulators do not yet know the extent of the contamination.

The cause of the maize contamination has yet to be determined. Mexico has never allowed the commercial growing of GE maize and since 1999 it has prohibited the release of GE maize for experimental purposes. Government regulators have speculated that contamination occurred when farmers planted transgenic maize that originated from the more than 5 million tons of maize that is imported annually from the United States.

## 1.2 CONTAMINATION RATES

The magnitude of the problem in Oaxaca is great. To put the contamination rates in perspective, we must consider a few statistics regarding maize and maize pollen. Emberlin *et al* estimate that a typical maize field has 50,000 plants per hectare. A 1% contamination rate means that 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 200 meters of the crop field, transport of pollen over longer distances is possible – for example, bees can disperse pollen up to several kilometres. The potential for contamination of neighbouring fields is a serious reality.[2]

Moreover, researchers have shown that farmers share maize seed widely. Once traditional varieties become contaminated, it is likely that contaminated seed will be shared with others near and far. Contamination by seed sharing will dwarf the amount of contamination that happens through pollination.[3]

## 1.3 IN DEFENCE OF MAIZE

To assess the impact of GE contaminated maize, civil organisations (including Greenpeace) organised a public seminar entitled "*En defensa del maíz*" [*In defence of maize*] in Mexico City on 23 January 2002. Nearly 140 farmers', environmental, social and academic organisations met to discuss the problem.

The aim was to collectively draw up proposals and strategies for action at local, national and international levels to tackle the emergency facing Mexican maize. In this seminar, organisations undertook to urgently spread information about the contamination throughout the national territory and to form observation and monitoring committees.

During this seminar, research results were presented by the National Institute of Ecology (INE) and the Commission Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO). The researchers concluded that:

- The original results of Quist and Chapela were correct.
- The contamination by transgenes in the Sierra Norte de Oaxaca was not an isolated incident, but it could also have occurred in other regions of Mexico.
- The contamination of native varieties of maize by transgenic sequences posed a serious problem for Mexico as native maizes represent the genetic memory of traditional agriculture.
- Damage to the original gene sequences of native maizes could cause irreparable damage to the natural heritage of the country.
- This situation contradicts official national policy with respect to the moratorium on the planting of transgenic maize. It could have legal consequences for the country.

## 1.4 CORPORATIONS AND THE MEXICAN GOVERNMENT ARE RESPONSIBLE FOR MEXICAN MAIZE CONTAMINATION

Transnational corporations (TNCs), the inclusion of Mexico in the North American Free Trade Agreement (NAFTA), and the failure of the Mexican government to safeguard its farmers and consumers all play their part in this on-going case of contamination.

### Transnational corporations

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 four giants: Monsanto, Syngenta (merger of Novartis and AstraZeneca), Bayer (formerly Aventis) and DuPont.[4] The TNCs that produce GE maize are these same companies. One commercial strategy of these companies is to deny farmers their ancient right to save, exchange and replant seed, as GE seeds are patented and cannot legally be replanted. TNCs even bring to court those farmers who unknowingly infringe the corporate patents on those seeds when their fields involuntarily become contaminated through pollination.

These transnational corporations use double standards for release of GE crops within different countries. For example, the US Environmental Protection Agency (EPA) prohibits Monsanto from growing its Bt cotton in certain areas in the US because of concerns about gene flow to weedy relatives of cotton[5]. While all the GE companies producing transgenic maize, including Monsanto, are well aware of this restriction in the US they continue to not take similar necessary precautionary measures to protect Mexican maize diversity from gene flow.

### Imports of maize under NAFTA

Contrary to the recommendations of producers' organisations, maize was included in the negotiations for the North American Free Trade Agreement (NAFTA). The Mexican government argued that openness of commercial markets would encourage farmers to plant crops that were more competitive on the international market.

While maize production in Mexico has remained relatively constant at around 18 million tons per year, maize imports from the USA have grown exponentially with NAFTA, increasing from 287 thousand tons in 1993 to 5.3 million tons in 2002.[6]]. Between 1995 and 2002, maize imports from the USA exceeded import quotas by nearly double. The Mexican government has not encouraged domestic production, nor protected national producers by charging the allowable duty on these imports. As a result, national maize producers have been forced to compete with subsidised US maize sold at a price below its cost of production – inevitably making maize production unsustainable for local producers. *"This decision meant that the activities of around 2.3 million Mexican producers with farms of less than five hectares would not be competitive, that 4.7 million hectares would have to be sown with another crop and that production of 7.1 million tonnes of maize would cease on this area."*[7]

*"The* [Mexican] *government is assisting the maize importers, many of them multi-national companies, at the expense of most of the national producers. In 2001, half the duty-free import quotas were granted to nine companies: Arancia-Corn Products International, Minsa, Maseca, ADM, Diconsa, Cargill, Bachoco and Pilgrims Pride. These companies in turn present almost the only options for purchasing the harvest of producers".*[8] These imports contain 25-30% transgenic maize, which is entering the country without any regulation, any requirement for segregation, or any labelling.

## 1.5 A FAILURE OF GOVERNANCE

Every year Mexico imports over 5 million tons of maize from the USA in which transgenic and conventional varieties are mixed.[9]

Although the Mexican government confirmed in 2001 that native varieties of maize had become contaminated by maize transgenes, and despite the fact that people from all parts of the world have responded to this alarming information by petitioning the Mexican government to act to protect traditional maize varieties, virtually no measures have been adopted to stop the contamination let alone to reverse it. This means that, whereas in 2001 it was known that there was contamination in communities in the states of Oaxaca and Puebla, it may now be much more widespread.

In March 1999, when Greenpeace Mexico launched its genetic engineering campaign and reported that their country was importing transgenic maize from the United States of America because of loopholes in national legislation, they issued a warning about what is now fact: ‘our maize could become contaminated through these imports and this contamination could have serious effects and consequences. This means that these imports have to be stopped.’ The Mexican government could have prevented the current contamination, and along with the companies must be held fully responsible for the contamination.

## 2 THREATS TO THE ENVIRONMENT FROM TRANSGENIC MAIZE

Insect resistant (Bt) and herbicide tolerant GE maize are grown in vast areas of the USA. These types of GE maize are most likely contaminating the native varieties in Mexico. Predictable risks to the environment from this contamination include impacts on beneficial insect populations and impacts on soil fertility. In addition, there could be larger scale impacts on the environment through changes occurring at the ecosystem level brought about by these smaller scale effects. Finally, scientists are concerned about the loss of the use of an important organic pesticide – Bt – through development of resistance in target pest populations.

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

### 2.1 GE MAIZE VARIETIES IN MEXICO

The most prominent GE maize trait present in imported US maize is the Bt gene, as the majority of GE maize under cultivation there is Bt maize. The majority of these Bt maizes are designed to kill butterfly or moth larvae in order to control pest insects such as the European corn borer. More recently Monsanto has designed a Bt maize engineered to kill beetles (the target pest is the corn rootworm). This new Bt maize variety has been grown in field tests for several years and from 2003 is being commercially grown. Testing done by Greenpeace in 2002 found that 18-35% of the maize in railroad cars headed to Mexico was of a single Bt variety, Monsanto’s MON 810.

It is also possible that Roundup Ready and Liberty tolerant GE maize are present in US maize imported into Mexico; Greenpeace tests have also detected Monsanto’s Roundup Ready variety, GA21, in railroad cars headed to Mexico. In addition, StarLink (an unapproved GE maize variety with a potential allergen) may have contaminated Mexican maize. In 2000, StarLink was detected in a wide range of food products in the US, triggering a massive product recall with related costs estimated at almost $1 billion. Following this recall, and when StarLink varieties were apparently no longer being grown, contamination was detected again in US exports to Japan in 2003.

There is a possibility that other GE traits are present in the US maize exported to Mexico each year.[10] Experimental GE maize seeds are planted in the open environment in the US without adequate measures in place to protect against contamination. These experimental seeds include pharmaceutical producing GE maize varieties. The ProdiGene incident in November 2002 provides a good example of this type of pharmaceutical contamination of food crops. In this case an experimental crop of pharmaceutical producing GE maize was accidentally mixed with other grains, and luckily was detected before ending up in the food chain in the US. There are significant concerns that these types of GE traits might contaminate the centre of diversity of maize and by doing so, damage landraces or even teosinte.

## 2.2 IMPACT ON BENEFICIAL INSECT POPULATIONS AND OTHER NON-TARGET SPECIES

Successful pest control relies on keeping predators and pests in balance. It is estimated that 50% of control of pest species is achieved by predators, with pesticides contributing a further 10% (the remaining percentage is thought to be due to host-plant resistance and other limiting factors).[11] Bt plants may impact predators through consumption of toxic prey that have eaten Bt crops, and by temporary reduction of pest species to a level too low to sustain the predators.[12,13] This could lead to extreme fluctuations in pest levels, with epidemic outbreaks following initial elimination of both pests and predators.

Effects on beneficial predators have been demonstrated in laboratory studies: common lacewings (*Chrysoperla carnea*) showed increased mortality from eating prey insects fed on Bt maize as compared to non transformed maize.[14,15] In field studies, researchers have shown a significant trend of higher densities of lady-bird beetles (*Coleomegilla maculata*) in non-Bt maize.[16] Unfortunately little scientific work has been done to examine the impacts of Bt on beneficial insect populations in the United States, let alone in Mexico where completely different species are found.

As noted above, Bts are toxins that kill butterflies, moths, and beetles. The toxins are produced in all parts of the plant during its entire life cycle. If they are introduced into landraces or teosinte in Mexico, native species of butterflies, moths and beetles – non-target species – could be exposed and suffer negative effects, as in the case of the Monarch butterfly in the United States.[17]

## 2.3 IMPACT ON SOIL FERTILITY

When Bt spores are sprayed onto plants and the soil below them, as the pesticide is used by organic farmers, there is a rapid decline in its abundance and activity. This may not be the case if the Bt gets into the soil via plant tissue. Studies have shown that Bt crops may secrete the toxin from the roots into the soil.[18,19] It is possible that plant tissue or direct exudation of Bt into the soil could have undesirable effects on soil fertility and composition, via decreased rates of plant decomposition and declining species diversity of soil micro-organisms.[22]

The effects of these substances on important soil organisms and soil ecology and fertility are not known. There are a few studies indicating that there may be negative long-term effects from growing such GE crops. Both earthworms and collembola (other small soil-dwelling invertebrates) have been shown to be affected by *Bt* crops.[20] A recent study showed that earthworms fed with Bt maize litter under laboratory conditions started to lose weight after 200 days; this suggests that there could be long-term toxic effects on earthworms.[21]

## 2.4 ECOSYSTEM EFFECTS

GE maize, like any other GE crop, has potential impacts on agricultural, natural, and semi-natural ecosystems. Impacts may occur through the creation of invasive species, the loss of diversity in wild and weedy species, or through effects on non-target species, for example through increased presence of toxins such as *Bt* in the environment. Moreover, effects that happen at a small-scale, such as a decrease in local populations of beneficial insects, could become magnified over time and space, though interactions that those insects have with other plants or animals in an ecosystem. For example, butterflies are responsible for pollinating many flower species and serve as food for birds and other animals. Impacts on butterfly populations could have far-reaching effects at the ecosystem level.

Ecosystems are complex, and it is universally accepted that not every risk associated with the release of new organisms such as GE crop species can be identified, let alone evaluated. This is the case in Mexico as in any other region. The likelihood of unknown risks appearing increases with the frequency and scale of the release, so risks may not be identified or accurately evaluated by the use of field trials which by their nature have limited temporal and spatial scales.[22]

## 2.5 ELIMINATING BT AS AN EFFECTIVE ORGANIC PESTICIDE

Bt insecticides are toxic to certain pest insects, and are thought to cause little harm to humans or to most beneficial insects.[23] Bt has been the pesticide of choice for organic farmers for this reason, and was used commercially for more than two decades without reports of substantial resistance developing.[24] This is unusual, as insects generally evolve resistance to pesticides within about a decade.[25] Many species are now resistant to so many pesticides that they are difficult or impossible to control.[26] Resistance to Bt has started to emerge in field populations of the diamondback moth (*Plutella xylostella)* as a result of foliar applications of Bt.[27]

Bt plants express Bt throughout their growing season and throughout all tissues of the plant; the area of exposure of target pests to GE crops may be orders of magnitude greater than when the pesticide is used by organic farmers in foliar application. Both target and non-target species will ingest Bt for long periods, and may be affected in development stages that would be entirely unexposed to foliar sprays. Thus monocultures of GE varieties expressing Bt continuously will select intensely for resistance.[28]

## 2.6 HINDERING THE SWITCH AWAY FROM CHEMICAL FARMING

There are alternative approaches to genetic engineering for pest, pathogen and weed control that not only increase yields and reduce costs, but also have significant health and environmental benefits. Alternatives include increasing the diversity of crops in the field and the diversity of the surrounding areas, integrated pest management, and altered cultivation practices. Indications are that pest control benefits are profound, including far greater benefits for health, local economies, and preservation and enhancement of the agricultural and natural ecosystems. These methods are often low or no cost, and increased labour costs are quite frequently substituted for the purchase of imported chemicals, with the result that more of the revenue remains in the locality.[29]

The switch away from chemical controls has been fiercely opposed by the major chemical companies, which have invested considerable resources in promoting pesticide and herbicide use to farmers in developing countries.[30] It is these same companies – for example Monsanto, Bayer, DuPont and Syngenta – that are developing *Bt* and herbicide resistant maize.

# 3 TRANSGENIC MAIZE CONTAMINATION THREATENS MAIZE DIVERSITY

Mexico is the primary centre of maize genetic diversity – the region where maize originated and where the greatest diversity is found. Maize varieties, developed over millennia by indigenous farmers, as well as wild ancestors of maize, represent one of the world's most valuable reservoirs of genetic material for plant breeding – the foundation for global food security. Native maize diversity provides the raw material used by farmers and plant breeders to improve the quality and productivity of maize crops worldwide.

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.[31] In Mexico, the hundreds of landraces of maize are called *criollo* maize, and each variety has 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 maize stalks 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'. Teosintes, the closest wild relatives of cultivated maize, are found growing from Chihuahua to Oaxaca.

Scientists consider that the warnings given by some environmental and academic groups on the introduction of transgenic maize into Mexico must be heeded because Mexico is a centre of origin and genetic diversity for maize, and that conservation of that diversity should be an end in itself. But there are also significant economic and food security reasons for maize conservation: maize diversity has been and will continue to be essential for maize breeding. Massieu and Lechuga, for example, explain that *"The maizes of Mexico are of special interest due to their role in the development of the modern and highly productive varieties of America, in particular in the corn belt of the USA."*[32]

## 3.1 WHY CARE ABOUT GENETIC DIVERSITY IN CROPS?

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 they 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.

A diverse repository of genes is essential to breeders around the world. Genetic information for important characteristics such as disease and pest resistance, as well as for yield and flour quality, is continually sought and utilized in the breeding programmes of all of our major crop plants. This is why crop genetic conservationists concern themselves with preserving wild relatives of crop plants, as well as with 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 are found in small populations, making conservation difficult.

The genetic diversity of crops such as maize is directly related to food security. The absence of genetic diversity, conversely, can be linked to many of the major crop epidemics in human history. For example, in 1970, the Southern maize leaf blight disease attacked the maize crop in the southern United States. 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 US $1 billion.

Jack Harlan, the noted 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.[33] Genetic Resources Action International reports that *"only 20% of local maize varieties reported in Mexico in 1930 are still known."*[34] Contamination by transgenic maize is one more threat to the already endangered Mexican reservoir of maize diversity and the food safety of those farmers who consume what they sow.

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. For many Mexicans, maize is the most important contribution that their country has made to the world; it is seen as not only a basic foodstuff but also as a fundamental cultural element: maize is central to Mexico's history and identity.

Contamination of this nature cannot be considered merely a national problem. Impacts on the genetic diversity of Mexican maize could have direct repercussions on the diversity of maize and ecosystems in all of North and Central America and throughout the rest of the world. Mexico is one of the centres of origin for maize. To lose a variety of maize in Mexico is to lose it throughout the world.

## 3.2 GE CONTAMINATION AFFECTS TRADITIONAL MAIZE VARIETIES AND WILD RELATIVES OF MAIZE

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 and others have written extensively from the perspective of evolutionary biology on the threats that genetically engineered crops may pose to landraces and wild relatives. Scientists consider two threats most important: demographic swamping (sometimes termed outbreeding depression) and genetic assimilation.[35] [36] [37]

In addition to these threats, Rafael Ortega Paczka, a specialist in maize and a researcher from the Autonomous University of Chapingo also notes that *"if the transgene contaminating the native varieties of maize gives this characteristics which are not acceptable to the farmers and the contamination continues for generations, the farmers will stop sowing the contaminated variety which would mean that valuable genetic information would be lost***"**.

### The special case of 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.

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 concern that such hybrids could become problem weeds, creating a nuisance for farmers and also out competing the wild relatives in the non-agricultural environment.

A second concern raised by scientists is the potential for a crop-to-wild gene flow to lead to the extinction of rare species. This extinction can happen in two ways – through demographic swamping and genetic assimilation. In swamping, the population of wild plants shrinks in size because crop-wild hybrids are less fertile. Small populations and rare species can be lost. The second process is known as genetic assimilation, where crop genes replace the genes in wild species through continual hybridization.

Recent research by scientists at the University of Wisconsin and the University of Minnesota found that genes from transgenic crops could rapidly take over those in wild relatives, such as teosinte.[38] The combination of the forces of swamping and genetic assimilation could then lead to what evolutionary biologists call a "migrational meltdown."[39] Most of the small populations of wild teosintes are already under serious threat. Contamination from an escaped transgene could push them over the edge.

# 4 TRANSGENIC MAIZE, TRADITIONAL AGRICULTURE, AND FOOD SOVEREIGNTY

Genetic contamination of maize threatens the food sovereignty for hundreds of millions of people that rely on maize as their primary source of food. Mexico has already witnessed the widespread destruction of local varieties and knowledge with the introduction of Green Revolution technology. The Green Revolution, while substantially increasing crop yields, obligated farmers to buy hybrid seeds dependent on chemical inputs and extensive irrigation. But more importantly, the Green Revolution destroyed crop diversity by supplanting local integral crop systems that were based on a wide genetic base and multiple use crops. Green Revolution crops displaced local varieties and forced farmers into a vicious dependency cycle. Genetic engineering of crops is an extension of this flawed paradigm.

As noted in the introduction to this report, Mexican agricultural and commercial policies, geared to the promotion of maize imports and to discouraging national production, are creating a range of negative socio-economic effects. These impacts affect those small-scale maize producers who are the majority of agricultural producers in Mexico; threaten their national food independence and self sufficiency as 25% of the national consumption of maize currently is covered by imports; and are ultimately responsible for transgenic contamination of traditional maize varieties in a key maize-growing country that is a centre of origin, diversity and domestication.

## 4.1 MAIZE IN MEXICO: NATIONAL PRODUCTION

Annually in Mexico, 3.2 million farmers produce 18.2 million tons of maize from a sown area of 8.5 million hectares, a similar area to that sown in the United States with transgenic maize. Despite fifty years of the Green Revolution in the country, hybrids of maize have not managed to penetrate 85 per cent of the territory that is still sown with native maize.

There are other important statistics on maize production:

- 72% of production units in Mexico grow maize, providing work for 35-40% of the total agricultural workforce and for 66% of the workforce concentrating on grains.[40]
- Maize generates one-third of the value produced in agriculture and represents over half the harvested area. It is a crop basically for the temperate areas that, in 1997, accounted for 65% of production and 85% of the total area dedicated to maize.[41]
- Maize is a crop grown mostly by small producers – 92% have farms of less than 5 hectares – of which personal consumption accounts for a large proportion (35% of these smallholdings).[42]
- In the last decade, 69% of maize sold came from smallholdings of between 2 and 10 hectares.[43]

## 4.2 NATIONAL CONSUMPTION OF MAIZE AND TORTILLAS

Maize is the basic foodstuff of the Mexican population. It represents half the total volume of foodstuffs consumed every year and provides the population with nearly half of the calories required. Nearly 60% of national production is destined for human consumption, including rural personal consumption. National consumption varies between 16 and 20 million tons. Industry mainly consumes imported yellow maize, on the order of 12.6 million tons per year. Only 1% of this demand is produced in Mexico itself.[44]

## 4.3 MAIZE CONSUMPTION AND CULTURE

Food culture in Mexico is very strong and there is a notable preference for consuming maize in an outstanding variety of forms: huitlacoche, cacahuazintle, tamales, tortillas, atole… the list goes on. Retaining this culinary diversity and defending its use is not just about the consumption of food: these foods are a fundamental component of the nation's cultural heritage. The fact that maize is the staple foodstuff of the Mexican population makes it an aspect of national stability, which is an important reason why the increasing dependence of the country on imports has created a climate of vulnerability and potential insecurity.

# 5 THREATS TO OTHER FOOD CROPS

As pointed out in an earlier section, centres of origin and diversity are important regions for the development of new breeds or varieties of crops. The introduction of GE species through import or by allowing commercial planting threatens biodiversity. Local cultivars and populations of wild relatives are vulnerable to genes outcrossing from new crop varieties. Gene transfers could lead to the loss or permanent alteration of these wild species or landraces.

Such gene transfer could occur in any one of the crop species on which we depend for food. All our major and minor crops have centres of origin and diversity somewhere in the world, and all of these crops interbreed with wild relatives and traditional varieties present in those centres.[45]

In addition to direct impacts on crop diversity, the large-scale growing of all genetically engineered crops has given rise to a number of other serious concerns, including a potential increase in the persistence and impact of weed species – one of the main hazards associated with herbicide resistant (HR) crops.[46] Below we discuss some of the major crops that have already been genetically engineered and specific problems that might result from contamination in their centres of origin.

## 5.1 SOYA

China is the centre of origin and the centre of diversity for soybeans, with more then 6,000 wild soya varieties, constituting over 90% of the global total.[47] GE soya contamination in China would result in similar ecological and cultural damage as GE maize contamination in Mexico. China is the largest importer of US soya in the world; 75 % of US soya grown in the US in 2002 was GE.[48] Although China does not allow the commercial growing of GE soya and has decided to keep its major soya-growing region in the northeast GE free, contaminated imports obviously present a serious risk to China's soya diversity.

GE soya varieties have been approved for planting in Canada, the United States, and Argentina. These varieties include Bayer's LibertyLink soya (glufosinate tolerant), Monsanto's Roundup Ready soya (glyphosate tolerant) and DuPont's soya with high levels of oleic acid in its oil.

Agronomic problems have already been observed with the use of GE Roundup Ready soya, although it has only been commercially grown since 1995. Scientific studies published in 2001 showed that yields with GE Roundup Ready soya were reduced in comparison to conventional soya.[49] These scientific studies demonstrated that a 5% yield suppression was related to the gene or its insertion process and another 5% suppression was due to cultivar genetic differential. The scientists concluded that yield suppression appears to be associated with the Roundup Ready gene or its insertion process rather than glyphosate itself.[50] Research also indicates that Roundup Ready soya has an increased lignin content, which may have been responsible for Roundup Ready soya plants becoming brittle in hot temperatures.[51]

Weed shifts are occurring in areas planted heavily with Roundup Ready GE soya beans; in both the United States and Argentina Roundup-tolerant weeds are becoming common. To manage these new weeds, farmers have to increase the quantity or change the types of herbicide used to fill gaps in control.

## 5.2 OILSEED RAPE

Europe is the centre of diversity of oilseed rape – the plant was introduced onto the North American continent only recently. In Europe, domestication is believed to have occurred in the early Middle Ages, and commercial plantings of rapeseed were recorded as early as the 16th century. Today China, India, Europe and Canada are the largest producers. Genetically engineered oilseed rape is a particular threat in Europe, where 900 species of the Brassica family can be found; there are many related plants growing in close proximity to cultivated oilseed rape.

There are eleven GE oilseed rape varieties commercially available in the United States and fourteen in Canada. Most are engineered to be resistant to a specific company's own brand of herbicide. These include four varieties of Monsanto's Roundup Ready glyphosate tolerant rape, three varieties of Bayer's LibertyLink glufosinate tolerant rape, five varieties of Bayer's InVigor tolerant rape, one Rhone-Poulenc bromoxynil tolerant rape and a Monsanto lauric acid producing rape.

Natural biodiversity could be placed at special risk by gene flow from GE oilseed rape to wild relatives; new weeds could be created when wild relatives receive novel genes that allow them a competitive advantage. France does not allow the growing of GE oilseed rape because of these concerns and Greece has prohibited their importation for the same reasons.

Volunteer oilseed rape weeds tolerant to three herbicides (Liberty, Roundup and Clearfield) were first identified in Canada in 1998 – just three years after GE herbicide tolerant oilseed rape was first grown[52,53]. According to Martin Entz, Professor of Agronomy at the University of Manitoba, Canada *"GM canola has, in fact, spread much more rapidly than we thought it would. It's absolutely impossible to control... It's been a great wake-up call about the side effects of these GM technologies."*[54]

## 5.3 MUSTARD SEED

Mustard seeds were being utilized in Greece and Egypt over 4000 years ago but are now grown worldwide. They were transplanted to India and other Asian countries in medieval times and imported into the Americas by Spanish missionaries. In California, wild mustard is now a common weed whose yellow flowers can be seen widely beyond the trails to missions alongside which they were first planted. Mustard is a member of the Brassica family and can interbreed with oilseed rape.

Mustard is an important food crop in India, which has led Pro-Agro Seeds India, the Indian arm of the multinational Bayer, to develop a genetically modified mustard seed. Pro-Agro has developed this seed to resist glufosinate, its own brand of herbicide; in-built male sterility for hybrid development will be forcing farmers to buy new seed every year. There is also currently work on a vitamin A-enhanced GE mustard seed.

## 5.4 RICE

Rice accounts for 11% of world cropland and supplies 20% of the world population's calories; by all accounts it is a major crop worldwide. It is generally accepted that rice was domesticated separately in Asia and Africa, resulting in *Oryza sativa* and *O. glaberrima* respectively[55,56] although cultivation of *O. sativa*, the Asian species, occurred much earlier and has since spread to every continent except Antarctica.

Overlap of rice cultivation with both weedy species and wild relatives is extensive: the greatest proportion of world cultivation is produced close to its major centre of diversity in South East Asia. There is extensive evidence of low-level hybridisation with wild species and of rapid gene flow to weed species. It is generally accepted that gene flow will occur in the event that GE rice is extensively planted. Gene flow is also likely to occur between cultivars, particularly in cultivation areas where rice is grown on smallholdings.[57]

The first GE rice on the market is likely to be a LibertyLink (glufosinate) tolerant variety developed by Bayer. Indications are that it could be commercially grown in the United States as early as 2004. There are many more GE rice varieties in the pipeline, including Monsanto's Roundup tolerant rice, Bt rice, and a variety of rice resistant to bacterial blight.

## 5.5 WHEAT

Wheat was originally domesticated in the Middle East. Related species are commonly found in this region, and the area is a center of diversity. Wheat is grown on an enormous scale, with over 225 million hectares cultivated annually world wide between 1995 and 1997. The 560 million tons of wheat produced each year makes up more than one quarter of the world cereal output. Canada exports 2.1 million tons of wheat to the Middle East every year.[58]

Monsanto hopes to commercialise GE Roundup Ready wheat in the USA and Canada in 2004. Other types of GE wheat being developed include wheat varieties that are resistant to fungal or viral diseases, tolerant to drought, and that have better characteristics for baking and processing. GE wheat is also being used for producing pharmaceuticals.

Wheat can hybridise with jointed goatgrass - a weed of wheat in the USA, which causes losses of $145 million annually. If herbicide tolerance genes were transferred from GE wheat into goatgrass, thus making it more difficult to manage, economic losses could be great. The transfer of disease or environmental stress resistance genes could lead to better survival of the plants acquiring the foreign genes, and disruption of ecosystems could result if they survived and displaced other species.

# 6 CONCLUSION – ACTION IS NEEDED NOW TO PROTECT THE CENTER OF MAIZE DIVERSITY

GE crops have serious potential impacts on agricultural, natural, and semi-natural ecosystems. Impacts may occur through the creation of invasive species; the loss of diversity in wild and weed species; reduction in the effectiveness of natural pest control; and unknown long term effects to fauna and flora.

GE crop contamination in centres of diversity poses a major global concern and urgent measures must be taken to ensure the integrity of such centres. We cannot afford to let the very sources of our food supply become irreversibly contaminated.

## 6.1 ACTION UNDER THE CARTAGENA PROTOCOL ON BIOSAFETY

The Cartagena Biosafety Protocol will come into force on 11 September 2003. The international community has adopted this instrument to safeguard the environment, biological diversity and human health from the irreversible risks posed by GMOs. It affords all nations the right to implement the precautionary principle, including by imposing bans or restrictions on the import and use of GE organisms when there is a lack of scientific knowledge or consensus regarding their safety. As such the protocol safeguards the basic right of a country to protect its biodiversity and the health of its people from transgenic crops and provides the means to free people from forced trade and to prevent dumping of GMOs.

There is an urgent need to implement and strengthen the protocol. The import of GE crops into there centre of diversity must be prohibited and companies must be held liable for any damage their GMOs may cause to the environment, biodiversity or human health.

## 6.2 ACTION IS NEEDED NOW

On 30 April 2002, the Senate of the Mexican Republic ratified the Biosafety Protocol and now has to implement it. **Greenpeace demands that the Mexican government develop and implement an emergency plan that includes the following actions to address the contamination of traditional maize varieties:**

- Undertake immediately an assessment of the scope and magnitude of the contamination in Mexico and of the GE crop 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 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 the production and dissemination of GE maize

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