

Woman selling local vegetables at a roadside market in Mandawa, Northern Rajasthan, India.



food
sovereignty

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who benefits from gm crops?

the great climate change swindle

september 2010 | issue 117



**Friends of
the Earth
International**



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executive summary

Every year, the International Service for the Acquisition of Agri-Biotech Applications (ISAAA), which is partly funded by the biotech industry, publishes figures on the cultivation of genetically modified (GM) crops around the world. This annual review is never short on hyperbole and focuses almost exclusively on what ISAAA considers to be the successful expansion of GM crops. But the evidence provided to back up ISAAA's claims is often weak, and there are questions concerning the accuracy of their data and conclusions.

Friends of the Earth International also publishes a fully-referenced annual report, 'Who Benefits from GM Crops?' which analyzes the area of GM crops in the world, assesses their impacts, and examines the biotech industry's data and promises. This year's report shows that in contrast to ISAAA's claims, there is significant and growing opposition to GM crops in many parts of the world. This is particularly the case in Europe, where planting decreased for the fifth year in a row, and Germany became the sixth EU country to ban GM maize MON810, the only GM crop authorized for cultivation in Europe. Similar caution is also being exercised in Africa, and in India, which recently placed a moratorium on planting its first GM food crop, Bt brinjal. Overall, GM cultivation remains largely confined to just six key countries: the US, Brazil, Argentina, India, Canada and China grew over 95% of GM crops in 2009. The remaining 19 countries ISAAA lists grew just 7 million ha between them.

In the key GM-growing countries serious concerns continue to arise about the social and environmental impacts of GM crops. This is particularly the case for herbicide tolerant (HT) and insect resistant (IR or Bt) GM plants in the Southern Cone of America¹, which is a region of prime importance for global food production, as well as for its unique biodiversity. In the US the government has also launched an investigation into the impacts of monopolies in the GM seed sector.

pesticide use on gm crops continues to rise

The development of herbicide resistant weeds means that a cocktail of herbicides is increasingly being applied to GM crops, exacerbating pollution and health problems. For example, in the Southern Cone, during the last season, around 200 million liters of biocides were used on soy crops (including the highly toxic organochlorine endosulfan, which is banned in many countries around the world); and 350 million liters of glyphosate (the active ingredient in Monsanto's Roundup herbicide) were applied to the area cultivated with GM soy. Further controversy erupted in Argentina following the publication of research into the impacts of glyphosate on embryo development.

The agro-chemical industry's solution to the problem of weed resistance is to use yet more (and different kinds of) herbicide, and to develop new GM crops that tolerate a range of different herbicides. Yet this solution will lead to further increases in dependency on fossil-fuel based chemical weed control.

In 2009 several new GM varieties were also approved for cultivation in the Southern Cone, and there is evidence of some GM crops varieties being cultivated without national authorization. Increasingly, vast GM plantations are displacing more and more peasant and Indigenous communities, destroying peoples' livelihoods and their ability to feed themselves. This displacement often involves the violent eviction of farmers from their lands. The agricultural frontier is also pushing ever deeper into the forests, contributing to deforestation and climate change.

In the US, new research, which analyzed United States Department of Agriculture data, also found that GM crop acres in the US were treated with over 26% more pesticide per acre than conventional varieties.

Some farmers in the US are also using paraquat and 2,4-D (a component of Agent Orange) on their soybean crops.



Deforestation in Brazil.

¹ The geographic region composed of the southernmost areas of South America, south of the Tropic of Capricorn.

executive summary

continued

Even though claims that genetically modified (GM) crops can solve hunger and poverty remain unproven, a new claim has recently emerged: that GM crops will be one of the solutions to combating climate change. This is a myth because:

- **gm crops are not designed to increase yields or store more carbon in plants** The GM industry makes a point of claiming that GM crops reduce pesticide use and increase yields, meaning that they will be useful in both tackling and adapting to climate change. On the basis of these claims, the industry is lobbying hard at the UN's climate change negotiations, in order to have GM crops and industrial farming methods recognized (and financed) as climate change mitigation techniques. But this report finds the industry's claims are exaggerated and premature.

For example, none of the GM crops so far developed for commercial cultivation have been specifically designed to be yield enhancing, and there is no evidence to support this claim. The GM industry's focus has actually been on agronomic traits: over 99% of commercial GM crops are modified to create pesticide-promoting herbicide tolerance or insect resistance (or both). In addition, there has been no success in improving crops' efficiency in carbon storage by genetically modifying their ability to metabolize carbon.

- **There are no drought and salt tolerant crops** Much is also made of 'miracle' GM crops that would be capable of growing in 'marginal lands' or dealing with abiotic stresses such as salinity, high levels of aluminum in soils, or drought. But in reality such crops are nowhere near commercial cultivation and these claims are highly speculative. Successful genetic modification conferring drought tolerance, for example, has so far proved impossible because it requires major changes to the metabolism of plants. It is also worth pointing out that no seed will germinate and flourish in the absence of moisture.

Furthermore, the idea that there are vast areas of 'marginal land' ready to grow GM crops for food and agrofuels is increasingly recognized as spurious. Recent reviews of this important issue, found that such land is rarely idle. It is more likely to be used by pastoralists, smallholders, Indigenous Peoples and women who utilize the land in a sustainable low impact way for hunting, and gathering food, fuel and building materials. In addition, land may also be important for biodiversity and protecting water resources.

- **gm crops do not store more carbon in soils or reduce fertilizer use** An additional new argument being used by the biotech industry is that GM crops will reduce the loss of carbon from soils by decreasing tillage (plowing). But this type of 'conservation tillage', originally intended to enhance soil and water conservation, was developed well before the first genetically modified crops and can be used with any crop. Furthermore, the introduction of GM herbicide tolerant crops is actually undermining the sustainability of these earlier conservation tillage systems, by increasing the quantity of pesticides used, and because of soil compaction by heavy machinery. Recent studies suggest that 'no-till' techniques may not sequester any more carbon than conventional plowing.

The holy grail of the biotech industry is the development of nitrogen-fixing crops that would reduce the need for artificial nitrogen fertilizers. In theory, these would also reduce the need for fossil fuels to manufacture, pack, transport and broadcast the fertilizers, thereby reducing greenhouse gas emissions from agriculture. But again there has been very little progress in terms of developing GM nitrogen-fixing crops, and a 2005 FAO report concluded that this may be technically difficult to achieve.

- **there are major risks associated with gm trees and gm agrofuels** GM trees are also being promoted as carbon stores. But the risks associated with GM trees are far more complex to assess since trees are organisms with large habitats and numerous interactions. In addition, both scientific literature and in-field experience show that contamination by and dispersal of GM trees will take place, and transgenic sterility is not an option. GM material from trees is likely to cross national borders making national regulation insufficient.



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Close up of a Soya plant that has just been sprayed in Paraguay.

Another claim by the GM industry is that crops should be genetically modified to improve fuel production. This is one area of GM development that is already well underway: 99% of the world's current GM crop is being grown for use as animal feed and fuels rather than food. But there is evidence that some crops such as GM Roundup Ready soya could increase greenhouse gas emissions (if land use changes are taken into account).

- **biotech companies' patents threaten our ability to tackle climate change** GM companies such as Monsanto, Bayer, Syngenta, BASF and Dupont have also been systematically patenting naturally occurring genes which could at some point in the future be included in crops modified to mitigate and adapt to the stresses brought about by a changing climate, such as drought, salinity, floods, and high and low temperatures. So far they have filed 532 patent documents covering 55 patent families. But the privatization of genetic resources in this way restricts farmers' and researchers' access to seeds and knowledge, both now and in the future.

In fact, corporate concentration in the biotech industry in the US seems to have reached such an advanced stage that the US Department of Justice has now launched an unprecedented sector-wide investigation. This will include an investigation into Monsanto, which dominates the GM seeds market, both globally and in the US. Monsanto has been accused of manipulating prices and deliberately suppressing the sale of competitors' products, including by rival DuPont. This investigation will include joint Department of Agriculture and Department of Justice workshops to look into the issue of competition in the agriculture sector, which is unprecedented in the US. The first of these workshops has already been held, in Iowa, and focused on GM seeds.

there is another way

GM crops are not necessary. There is another highly successful approach to agriculture that already has a proven track record when it comes to addressing some of the challenges linked to food production and climate change - agro-ecology. This approach incorporates a range of sustainable food production systems, which focus on preserving biodiversity and increasing food productivity. Agro-ecology also ensures that carbon rich materials, such as manure and compost, are systematically returned to the soil to improve it. Many recent studies have identified agro-ecology as key to facing future food challenges, including those of the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) (April 2008), and the UNEP-UNCTAD Capacity-building Task Force on Trade, Environment and Development which published a report on "Organic Agriculture and Food Security in Africa," in October 2008.

However, many agro-ecological solutions to the major problems of drought and saline soils have still to be extended to farmers. There is a persistent failure to make money available to fund extension services and infrastructure. In some countries lack of land tenure for farmers, and especially women, also makes the adoption of agro-ecological practices more difficult.

Farming practices still need to change radically to meet the challenges of a warming climate. These will include feeding a growing population, protecting and restoring biodiversity and ecosystems services, and producing fuel and raw materials for industry. But the good news is that with political will and support, agro-ecology can do all this.

one genetically modified crops – the global picture

genetically modified crops – the global picture

The biotechnology industry spends considerable amounts of time and money producing materials that claim to show a rapid expansion in the area of land planted with GM crops. They aim to use these materials to try to persuade countries or regions that have not wholeheartedly taken up GM crops that they will be left behind by the 'gene revolution'. They also contend that miracle GM traits about to be brought to the market are needed to feed people in a warming world. However, the evidence to support these claims is very weak.

1.1 gm crops are not being grown to feed people

Despite more than 30 years of research and development, GM crops have made little impact in terms of their contribution to global food supplies, despite their continued promotion as 'part of the solution' to alleviating hunger.

In fact, most GM crops are not grown to produce food for people. They are being grown to provide animal feed, agrofuels (in the form of bio-diesel and bio-ethanol) and cotton. For example, somewhere between 60% and 90% of the GM soya harvest is used for producing high protein soya meal for animal feed, and vegetable oil (MVO, 2009). Some of this oil is used for cooking, but in Argentina, Brazil and the US significant amounts are converted into bio-diesel.

GM maize is also converted into animal feed in the form of grain or maize gluten. Some maize oil and corn syrup is used in cooking and processed food, but significant quantities are now being diverted to agrofuels production. GM canola (oil seed rape) is also used to produce vegetable oil and crushed seed to feed to livestock.

According to industry sources over 99% of the GM crops planted commercially are soya, cotton, maize or canola. In 2009 GM soya alone accounted for over half of all the GM crops grown (52%) and maize nearly one third (31%) (ISAAA, 2010).

In contrast, there are so far no commercial GM varieties of wheat, barley, oats, rice, potatoes, sorghum, millet and other pulses. Similarly, the commercial production of GM fruit and vegetables is confined to just a few small locations: GM papayas in Hawaii and China, and GM tomatoes and sweet peppers in China. Thus nearly all the cereal, pulses, fruit and vegetables consumed on the planet remain non-GM.

A global area of 134 million ha of GM crops was cultivated in 2009 (ISAAA, 2010). In addition GM poplar trees are also grown in China, and GM flowers in Australia, Colombia, China and Japan (ISAAA, 2009; ISAAA 2010).

box 1: what is isaaa?

The International Service for the Acquisition of Agri-Biotech Applications (ISAAA) has a very definite pro-GM mission. As it explains on its website "ISAAA is a not-for-profit international organization that delivers the benefits of agricultural biotechnology to resource-poor farmers in developing countries." (ISAAA, 2009b) ISAAA also describes itself as being "principally sponsored by philanthropic foundations, and cosponsored by a donor support group consisting of public and private institutions." (ISAAA, 2009b) However, this donor group includes Monsanto and Bayer Crop Science, CropLife International (a global biotech lobby group), USAID and the US Department of Agriculture, together with the governments of Kenya and the Philippines.

There are significant questions about the accuracy of the data they issue. In particular, the sources of data used in the global status report are sometimes unclear. For instance, the online PowerPoint presentation of the 2008 Global Status Report simply cites the source as "Clive James 2008" (Clive James is the Chair of ISAAA). In addition, apart from the US, very few governments record the area of GM and non-GM crops separately, so data is collected per crop. This means that ISAAA must generally rely on industrial data for seed sales to calculate how many hectares have been planted with GM crops (although China poses more difficult problems because the seeds come from several public institutions) (ISAAA, 2009c).

Left & Right: Market stands in Mandawa and Fatephur, Rajasthan, India.



1.2 resistance to gm crops remains strong

Every year, the International Service for the Acquisition of Agri-Biotech Applications (ISAAA), which is partly funded by the biotech industry, publishes figures on the cultivation of GM crops around the world. But this annual review is never short on hyperbole, focusing almost exclusively on what it considers to be the successful expansion of GM crops (ISAAA, 2009; ISAAA 2010).

In reality there is significant opposition to GM crops in many parts of the world, with countries and governments remaining extremely cautious about the adoption of genetic technologies, especially in food crops. Eurobarometer figures, for example, show that public opposition to GM in the EU is 58%. India has just banned the planting of its first GM food crop, Bt brinjal, due to widespread public opposition, and South Africa has also stopped planting GM food crops due to safety concerns (Africa Biosafety, 2009; India, MOES 2009; EC, 2005).

The 2009 ISAAA report also makes much of small areas of GM crops being planted in various countries. Yet a closer analysis of the data reveals that little progress is really being made outside the six countries that grow the majority of GM crops; and in some areas the expansion process has come to a standstill. The US, Argentina, Brazil, India, Canada and China grew over 95% of GM crops in 2009, with the first three countries accounting for 80% of the total. The remaining 19 countries that ISAAA listed as growing some GM crops in 2008 grew just 7 million ha between them – equivalent to 11% of the US's crop (ISAAA, 2010).

In its 2009 Global Status Report, ISAAA stated that the “*number of farmers benefiting from biotech crops...reached 14.0 million, an increase of 0.7 million over 2008...over 90%, or 13.0 million (up from 12.3 million in 2008) were small and resource-poor farmers from developing countries.*” But such figures need to be put into a global context to have any real meaning. There are 513 million small and medium-sized farmers in the world with farms below 10 ha (Von Braun J, 2008) so even if ISAAA figures are correct only 2.5% were growing any GM crops in 2009.

ISAAA's 2008 report's claim that there has been a “*new wave of adoption of biotech crops*” because the number of countries planting biotech crops has “*soared*” to 25, was unjustified. The number of countries planting biotech crops in the previous year was 22 so the difference – just three countries – is not that dramatic (the additions were Bolivia, Burkina Faso and Egypt); and GM crop production remains insignificant in terms of world agricultural production, as Figure 1 shows. This hardly constitutes a “*historic milestone*” (ISAAA, 2009). Furthermore, in 2009, the number of countries did not increase at all (although Costa Rica took up GM farming, Germany dropped it) (ISAAA, 2010).

Table 1 also shows how little GM cropping really takes place, with non-GM food and fodder crops taking up over 97% of the world's agricultural land and over 90% of the world's arable land in 2009.

FIGURE 1

GM CROPS AS A PROPORTION OF GLOBAL AGRICULTURAL AND ARABLE LAND

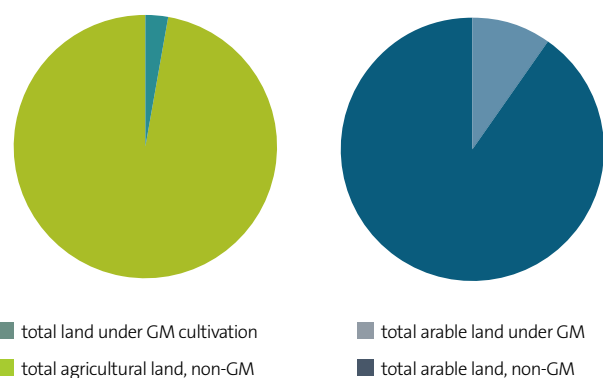


TABLE 1

GM CROPS AS A PROPORTION OF GLOBAL AGRICULTURAL AND ARABLE LAND

	TOTAL GLOBAL LAND (ha) ^a	TOTAL AREA UNDER GM CULTIVATION (ha) ^b	TOTAL AREA UNDER NON-GM CULTIVATION (ha)	GM AS A PERCENTAGE OF GLOBAL LAND (AGRICULTURAL/ARABLE)
Agricultural land	4,803,385,400	134,000,000	4,669,385,400	2.8%
Arable land	1,365,069,800	134,000,000	1,231,069,800	9.8%

Sources: ^a (global) www.nationmaster.com/graph/agr_ara_lan_hect-agriculture-arable-land-hectares
http://www.nationmaster.com/graph/agr_ara_lan_hect-agriculture-arable-land-hectares;

^b International Service for the Acquisition of Agri-biotech Applications <http://www.isaaa.org/resources/publications/briefs/41/executivesummary/default.asp>

one genetically modified crops – the global picture

continued

1.3 data tricks

Organizations such as ISAAA have a vested interest in inflating the uptake of GM to ensure a continuing supply of investment from donors (see box “What is ISAAA?”). Thus they usually employ a number of tricks to boost the figures they present each year. These include double counting, inflating figures by rounding the smaller ones up to a minimum figure, the incorporation of uncertain data (‘ghost hectares’), and exaggerating the impacts on small farmers.

1.4 double counting

Two types of traits account for around 99% of GM crops grown – herbicide tolerance (HT) and insect resistance (IR). Biotech companies have started to combine these traits in one crop by cross-breeding to produce what are known as ‘stacked GM traits’. Monsanto and Dow, for example, have developed a maize variety called SmartStax (Monsanto, 2007) containing eight genes that affect three traits, influencing herbicide resistance and under- and over-ground insect resistance.

In their 2009 report, ISAAA claimed global hectareage of biotech crops continued its strong growth in 2009 for the fourteenth consecutive year. But they still characterize the 9 million ha increase in land area under GM cultivation (bringing the total to 134 million ha, equivalent to a 7% increase on the previous year) as “*apparent growth*.” They go on to describe the “*actual growth*” as growth in “*trait hectares*.” This allows them to inflate the rate of growth to an 8% year-on-year increase, since the hectareage of “*trait hectares*” has increased by 14 million ha, to a total of 180 million (ISAAA, 2009). This means that for crops with two or three stacked traits, ISAAA is claiming double or triple the area.

1.5 inflating the figures

For countries that have only grown very small areas of GM crops, the ISAAA's Global Status Report records them as <0.1million ha. This can be extremely deceptive. In 2007, for example, ISAAA recorded the areas of GM maize planted in Poland and Romania as <0.1 million ha when they were actually 327 ha and 350 ha respectively (Monsanto, 2008). Similarly, in its 2008 report ISAAA recorded the GM maize area in Spain as 0.1 million ha, which inflated the actual figure of 79,267 ha by 26%.

1.6 ghost hectares

In previous Global Status Reports, figures quoted for GM crop cultivation have been challenged or found to be inaccurate.

In 2005, for example, the area given by ISAAA for GM maize in the Philippines, where no official statistics were gathered, was challenged. ISAAA claimed that more than 50,000 ha were cultivated with GM corn. However, the Philippine government does not monitor the actual areas planted with GM corn, nor does it have a system to track the amount of GM corn seeds that have been sold to farmers. When ISAAA director Dr. Randy Hautea was asked about the source of these statistics, he replied that they came from the Department of Agriculture in the Philippines. However, the Philippine Bureau of Agricultural Statistics has no figures on the hectareage or number of farmers using GM corn, and an official from the government said that ISAAA's claim was superfluous (FOEI, 2006:6).

The data for GM cotton in South Africa was also contested (De Grassi A, 2003) because the actual area appeared to be 20 times less than ISAAA's claimed 100,000 ha.

In 2006 the Global Status Report claimed GM rice was being grown in Iran, which was challenged by the International Rice Research Institute (Financial Express, 2006). The 2007 report did not mention GM rice in Iran.

1.7 exaggerating the impact on small farmers

In its 2009 Global Status Report, ISAAA stated that the “*number of farmers benefiting from biotech crops...reached 14.0 million, an increase of 0.7 million over 2008...over 90%, or 13.0 million (up from 12.3 million in 2008) were small and resource-poor farmers from developing countries*.” But such figures need to be put into a global context to have real meaning. There are 513 million small and medium sized farmers in the world (with land holding below 10 ha) (Von Braum J, 2008), so even if ISAAA figures are correct only 2.5% were growing any GM crops in 2009. In reality, GM crops are grown by a tiny proportion of small or medium scale farmers worldwide: at the most this is less than 1% of all farmers.

2 ISAAA calculates trait hectares by multiplying the actual surface area by the number of GM traits in the crops. So, a field of one hectare growing a GM crop which is tolerant to two herbicides and secretes insecticide toxin (three traits) suddenly becomes three fields.

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Crop spraying.



two promises, promises – the claims of the biotechnology industry

promises, promises – the claims of the biotechnology industry

Researchers in the field of biotechnology require an ongoing flow of funds to conduct their research, regardless of whether they are academic or working within the industry. They also compete with each other for both public and private funding. Consequently there is a strong tendency to exaggerate the future potential of the genes that have been identified.³

Ultimately, researchers expect the results of their GM research to be bought up by agri-biotech companies, which will then develop crops that can be sold to farmers on a commercial scale. From the companies' perspective, the potential for repeat sales will also be a significant factor in determining which traits to buy.

However, it is a very big step from identifying a gene with a particular function to being able to engineer that gene into a plant in such a way that it functions consistently and reliably in the field. Many characteristics, such as drought tolerance and nitrogen fixation, are controlled by more than one gene, which makes the task of genetic modification all the more complex. The overall genetic make-up of the plant is also critical in determining whether a crop variety will be able to withstand a range of abiotic stresses, from drought to flooding.⁴

2.1 unfulfilled promise

The list of GM crops waiting in the wings is growing longer every year. More than 180 plant species have now been through the genetic modification process to the point where they have been field-tested (Dunwell J M and Ford CS, 2005) (ISB, 2010), yet very few have progressed to the stage where commercial seed is available to farmers.

The proponents of the biotechnology industry blame this on excessive regulation and the European Union's opposition to GM crops (US Senate Committee, 2009) (Hansard, 2008). However, even in the US, with its combination of a large market and less stringent regulation, there is little sign of GM traits reaching the commercial production stage. And even crops in the US face legal problems. For example, GM alfalfa deregulation was suspended in June 2009 (US Court of Appeals 2008) and GM sugar beet in September 2009, because of the US Department of Agriculture's failure to produce full Environmental Impact Statements (California, 2009). In both cases the judges were concerned that the environmental and socioeconomic impacts of cross-pollination had not been properly assessed by US regulators.

To date, thousands of potential GM plants have been tested in the US yet only two main traits – herbicide tolerance and insect resistance – have resulted in significant commercial production. According to one recent review from the EU's Joint Research Centre, there are 25 traits in the regulatory pipelines around the world – 60% of which are for HR and IR (Stein AJ and Rodriguez-Cerezo E, 2010). The same letter predicted that by 2015 the proportion of HR and IR crops would increase to 65%. The remainder would be traits for product quality, virus resistance, abiotic stress (one in the pipeline) and other traits.

Golden Rice has been a particular flagship project for the biotech industry over the last decade, as it has been portrayed as a crop specifically developed to alleviate Vitamin A deficiency in the Global South. However, major doubts still exist about its efficacy in tackling this one aspect of malnutrition, its performance as a crop, and public acceptance in target populations (ISIS, 2009) (Foodwatch, 2009).

One commentator from Institute of Nutritional Sciences in Giessen summed up these doubts:

"Until today, no research has been published indicating the nutritional benefit of this new rice whether alone or integrated in meals or consumed for a short or long time. What we also do not know is whether this much touted transgenic biofortified rice approach is superior to other conventional strategies for preventing and overcoming vitamin A deficiency." (Krankwinkel M, 2007)

³ In the early 2000s, for example, the UK Food Standards Agency (FSA) published an educational "time line" which predicted the availability of GM golden rice by 2004, high protein GM potatoes by 2004; salt tolerant tomatoes by 2005; sunflowers resistant to white mould by 2005; edible GM vaccines by 2010; disease resistant grapes by 2010; and caffeine-free tea and coffee bushes by 2010. None of these GM crops are anywhere near commercial development in 2010. (Wisely, however, the FSA included a disclaimer in its 'educational' tool.) (FSA, undated)

⁴ See Climate and GM chapter for detailed information.

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Soy crops.



three gm crops in the united states

gm crops in the united states

3.1 official data from US shows escalating pesticide use on gm crops

Recent developments in the US, one of just six key countries heavily engaged in growing GM crops, clearly illustrate the fact that GM crops are failing to live up to the biotech industry's promises, both in terms of reduced pesticide use and benefits to farmers.

The biotechnology industry assures its detractors that the introduction of GM crops will be beneficial because it reduces pesticide use. However, research published in the US in 2009 shows that although this might have been true in the first few years for corn, soybean and cotton crops, it is far from being the case now. North American farmers actually applied over 173 million kg (383 million pounds) more pesticide in the 13 years since GM crops were first sown in the US, than they would have done had they been farming with conventional seeds. This equates to an average increase of 0.11kg per acre per trait in the period since 1996.

Furthermore, herbicide use is also accelerating rapidly. 46% of the total increase occurred in 2007 and 2008. With respect to glyphosate (the herbicide used along with the most widely grown GM trait, herbicide resistance), the rate of application per crop since 1996 has tripled for cotton, doubled for soybeans, and increased by 39% for corn (Benbrook, 2009).⁵

One key reason for this startling increase in herbicide use is the overwhelming market dominance of Monsanto's Roundup Ready (RR) trait, which is modified to be resistant to Monsanto's glyphosate-based herbicide Roundup. The prevalence of the RR trait has led to widespread over-reliance on glyphosate, which has in turn resulted in the emergence of numerous glyphosate-resistant (GR) weeds, including GR *Palmer amaranth* and GR horseweed. These are some of the most invasive and noxious weeds in the US and Canada (Benbrook, 2009).

The rapidly spreading menace of these GR 'super weeds' means that farmers are having to develop alternative weed control strategies, which may include using a cocktail of different herbicides, and increasing the quantity and frequency of their application. It also means farmers are relying more on tillage, and even reverting to manual weeding. The spread of GR-resistant weeds is also increasing the risk that US farmers will resort to older, higher-risk herbicides including paraquat and 2,4-D (a component in Agent Orange), which would heighten the risk of widespread health and environmental risks, including birth defects and other reproductive problems, and have severe impacts on aquatic ecosystems.

Herbicide resistant weeds are not new, but GM crops create special circumstances. In particular, their use encourages applications of higher doses of herbicide, and they can also be applied at times not previously possible because the GM plants are resistant to the chemicals. The continued growing of Roundup Ready crops in the same place year after year, using the same herbicide – glyphosate – also facilitates the rapid development of these 'super weeds.' Additionally, farmers' reliance on glyphosate also means that GR-resistant weeds now pose a far greater threat to them than previous herbicide resistant weeds (Benbrook, 2009).

The biotech industry's response to GR-weeds is to develop further GM traits, endowing plants with resistance to a wider variety of herbicides. But this will eventually bring about the same problem with those other herbicides, meaning that fewer and fewer herbicides are eventually available for pest control. One company has also been granted a patent covering HT crops that can be sprayed with herbicides from seven different families of herbicides, giving rise to the prospect of next generation crops being treated with even greater quantities of herbicide (Benbrook, 2009).

3.2 gm crops lock farmers into expensive and unsustainable practices

Farmers wanting to switch away from Roundup Ready products cite the difficulty of dealing with GR weeds, the increasing price of Roundup Ready seeds, the fact that they cannot save seed from one year to the next, and the premium prices they receive for non-GM soybeans (Benbrook, 2009). Non-GM soybeans can also be sold to markets that will not accept GM soy.

Weed resistance leads to increased herbicide use and more manual labour, meaning that costs are likely to be significantly increased. Under average yields and market prices, for example, soybean farmers may see total cash operating costs exceeding US\$494 per hectare, leaving just US\$74 per hectare to cover all other fixed costs and income (Benbrook, 2009).

At the same time, the cost of buying the Roundup Ready trait is spiraling, and farmers are also being pushed into buying the more expensive GM-seeds, with three or more stacked traits (Benbrook, 2009). This is a direct result of concentration of ownership in the biotech sector in the US (and globally).

⁵ The average annual increase works out at 18.2% for cotton, 9.8% for soybeans and 4.3% for corn.

Yet farmers seem to have little choice at present. For example, although farmer demand for conventional soybeans is outstripping availability in some states, and the US area planted with HT soybeans decreased by 1% in 2009, there is very little non-GM seed available.

3.3 monopoly control of biotech companies in the US – a cautionary tale

Most of the chain of activities involved in the production of food, from the sale of seeds and inputs such as pesticides and fertilizers, through to the processing, packing, distribution and sale of foods, is increasingly dominated by a small number of ever more powerful corporations. The principal exception to this tends to be the riskiest link in the chain: the uncertain task of actually growing and harvesting crops and rearing farm animals is often left to individual farmers, big or small. But farmers are also dictated to by the giant biotech companies who are able to use their dominant market positions to shape the market in their own interests, restrict further competition and stifle innovation (AAI, 2008).

The relentless concentration of corporate power in the food sector, both horizontally and vertically, is especially evident in markets supplying seed to farmers. In particular, a series of corporate mergers and buyouts combined with the expense and complexity of patenting new plant varieties have pushed hundreds of smaller companies out of business.

This concentration of ownership and control over key plant genetic resources also characterizes the US seeds sector, where at least 200 independent seed companies have gone out of business in the last 13 years (Hubbard, 2009). Globally, four seed firms - Monsanto, Syngenta, DuPont (Pioneer) and Limagrain - now control about 29% of the world market for commercial seeds (Hendrickson and Heffernan, 2007). When it comes to genetically modified seeds, Monsanto is the clear front runner: Monsanto's GM corn, cotton and soybean seeds are planted on more than 90% of the land under GM cultivation. Syngenta comes in second, with its seeds sown on just 4% of the remaining GM area (Hendrickson and Heffernan, 2007). In addition to mergers and acquisition this dynamic has been fuelled by:

- *The prohibitive cost of biotechnological research, which favors large firms*
- *A failure to effectively enforce anti-trust laws*
- *Patents being granted to agricultural biotechnology products, and*
- *Patents being awarded for inventions that were the result of publicly-funded research.*

In 2009, the proportion of US cropland sown with transgenic crops was 85% for corn, 87% for soybeans and 93% for cotton (USDA June Agricultural Survey, referenced in (AAI, 2009)). Again, Monsanto is the dominant player: Monsanto sells 93% of the US's soybean seeds and 80% of its corn seeds (Hubbard, 2009; Washington Post, 2009). Monsanto is now in such an unassailable market position that it seems to be able to adjust its prices and licensing conditions virtually at whim, ramping up its profits and further consolidating the dominance of GM seed varieties over conventional ones.

In 2009, for example, corn seed prices increased by 30% and soybean seeds by 25% (Hubbard, 2009:5). Increases in fees charged for genetic traits appear to be driving these sharp price hikes: a bag of Roundup Ready soybeans that cost US\$6.50 in 2000 can now cost nearly US\$17.50 (Hubbard, 2009: 22) and Monsanto's triple stack corn was also earmarked for a 30% price rise in 2009 (Hubbard, 2009: 25). Monsanto also appears to be pushing farmers into buying its more expensive triple stacked traits by increasing the prices and reducing the availability of its single and double stacked trait lines (Hubbard, 2009). Farmers report, for example, that they are finding it ever harder to find Bt corn without the Roundup Ready trait (Hubbard, 2009). One study also shows that farmers planting GM soybeans are now spending over 16% of their income on seeds (compared with soybean farmers spending 4-8% of their income on seeds in the years 1975-1997) (BusinessWeek, 2010).

3.4 US justice department initiates anti-trust investigations

The US's Department of Justice has recently opened an investigation into Monsanto's stranglehold on the US GM seed market and issues of concentration in agriculture more broadly. But it has been slow to address this problem in the past.

In 1997, Monsanto bought Holden Foundation Seeds, a major corn seed producer. At the time Holden was producing seed that was planted on about 35% of the US's corn acreage (New York Times, 1997). Seen as an expensive purchase at the time, this canny acquisition actually gave Monsanto a ready-made route for transferring its agricultural biotech products to the market place, and the ability to control access to corn seed germplasm, a key input for anyone developing new corn traits, including Monsanto's competitors. This concern was eventually acknowledged by the Antitrust Division of the US Department of Justice, but only in response to Monsanto's additional purchase of DeKalb Genetics Corp, when the Department of Justice insisted that Monsanto provide more access to Holden's corn genetics. It did not, however, apply the same requirements to Monsanto's other genetic lines (AAI, 2008).

three gm crops in the united states

continued

In the late 1990's, Monsanto had also planned to merge with Delta Pine and Land Co. (DPL), the largest seller of traited cottonseed in the US (DoJ, 2007), but the Department of Justice decided to investigate and Monsanto then abandoned the agreement (DoJ, 2007). DPL subsequently set about developing links with other biotech companies, including Dow AgroSciences, DuPont, Syngenta Crop Protection AG and Bayer CropScience, to develop new seed traits that it might use to replace Monsanto's (DoJ, 2007), thus undermining Monsanto's own relationship with the company. In response, Monsanto began building its own cottonseed business, Stoneville Pedigreed Seed Company, which it developed into the second largest (although still significantly smaller) traited cottonseed seller (DoJ, 2007).

A decade later, in 2007, the US Department of Justice again registered concerns about Monsanto and anti-competitive practices, but Monsanto was eventually permitted to acquire DPL in a US\$1.5 billion merger (DoJ, 2007b), subject to certain conditions (including the divesting of its Stoneville company, the return of a number of seedlines to Syngenta, and the removal of restrictions on competitors stacking other traits with its Roundup Ready trait) (DoJ, 2007b). In spite of these conditions, the acquisition still meant that Monsanto's competitors lost a major client, and the ability to use a key non-food crop as a means of testing the effectiveness of new traits (AAI, 2008).

However, in August 2009, because of persistent concerns about the fact that a few large firms continue to dominate the US seed industry, the US Department of Justice announced an industry-wide investigation into alleged anti-competitive conduct. This investigation will include joint Department of Agriculture and Department of Justice workshops to look into the issue of competition in the agriculture sector, which is unprecedented in the US. The first of these workshops has already been held, in Iowa, and focused on GM seeds. In addition, seven US state attorneys are investigating Monsanto in particular; and DuPont

Co. has accused Monsanto of anti-competitive practices (Dupont, 2009; BusinessWeek, 2010). DuPont is arguing that Monsanto is using the dominance of the Roundup Ready trait to suppress the sale of competitors' products, by making it hard for other companies to acquire a license to combine traits (Washington Post, 2009). Monsanto has accused and is suing DuPont for breaking an agreement not to stack the Roundup Ready trait with DuPont's own glyphosate-tolerant Optimum GAT trait (Monsanto, 2010).

While the giants of the biotech world fight it out for complete dominance of the food and farming sectors, farmers and consumers are suffering the effects. Clearly the corporate approach to seed production is not working for farmers. Developments in the US show that it is the big biotech and seed distribution companies that are the main beneficiaries of the introduction and development of GM technologies. Farmers are struggling with increasing prices for inputs such as seeds, and ever-higher operating costs, especially because of the spread of glyphosate resistant weeds.

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Harvesting of soy

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four gm crops in europe

gm crops in europe

4.1 another year of decreasing gm acreage in the european union

For the fifth year in a row fewer GM crops have been planted in the European Union. The number planted decreased by more than 10% in 2009.

TABLE 2

GMO CULTIVATION IN EUROPEAN COUNTRIES 2008/9

COUNTRY	2008 (HA)	2009 (HA)	YEAR ON YEAR CHANGE
Spain (1)	79,269	76,057	-4%
Romania (2)	6,130	3,094	-50%
Germany (3)	3,173	0	-100%
Czech Republic (4)	8,380	6,480	-23%
Slovakia (5)	1,931	875	-55%
Poland (6)	3,000	3,000	0
Portugal (7)	4,856	5,202	+7%
Total	106,739	94,708	-11%

Sources: 1. (Spain, 2009) 2.(INFOMG, 2010) 3.Nil after German national ban 4. (Greenpeace, 2010) 5. (Polonoinfo.sk, 2010) 6. Daily Rzeczpospolita, which quotes the estimates of Polski Związek Producentów Kukurydzy (The Polish Association of Maize Producers) and (FoEE, 2009) 7. Official Government figures. Available on request.

GM crop cultivation in the European Union has been the subject of much controversy over the last 13 years, because of concerns about the safety of GM crops, contamination and, increasingly, about the socio-economic impacts of GM cultivation.

In 2009 this trend was strengthened when Europe's largest country and agricultural heavyweight, Germany, banned GM maize MON810, the only GM crop authorized for cultivation in Europe. The ban was put in place on grounds of the threat it posed to the environment and health. 70% of the German public supported a ban on GM crop planting, reflecting continuing public opposition to GM across Europe. Germany's cultivation of 3,173 ha of GM maize fell to zero in 2009 following the national ban (Guardian, 2009).

"I have come to the conclusion that there are legitimate grounds to accept that genetically-modified corn from the MON810 strain constitutes a danger to the environment."

Germany's Minister of Agriculture, Ilse Aigner.

Source: (Bloomberg.com, 2010)

Europe's largest agricultural producer, France, decided to maintain its ban on MON810 in 2009; and Luxembourg also introduced a national ban, taking the number of countries in Europe with provisional bans on MON810 to six (these bans are based on the 'safeguard' clause in EU regulations).

New analysis of MON810's potential toxicity, based on Monsanto's own data, was also published in 2009 (Spiroux de Vendômois *et al*, 2009).

Four of the six countries have never permitted MON 810 cultivation; France (2008) and Germany (2009) are significant because they are the first to have banned the crop *after* it was first cultivated. This was a major blow to the GM industry in Europe, especially as the total area under GM crops fell by 2% between 2007 and 2008 due to the French ban (FoEE, 2009). In 2009, the area cultivated in the six EU countries still planting GM crops was 12,969 ha smaller than in 2008, a decrease of 12%: in 2008, it stood at 107,719 ha, which includes 3,173 ha in Germany, but in 2009 it fell to 94,750 ha (ISAAA, 2010).

In fact, no GM crops have been approved for cultivation in the European Union since 1998, and many applications that were pending in the late 1990s have now been withdrawn. The same reluctance to cultivate GM crops is evident in other non-EU European countries as well, including major agricultural producers such as Russia and Ukraine where no GM crops have so far been approved for cultivation.

The European Commission did attempt to force member states to accept GM maize, but these efforts were met with resistance when the European Council of Ministers rejected an EC proposal intended to force Austria and Hungary to lift their national MON810 bans.

Spain is now the only country in the EU which has a substantial area of MON810 cultivation but official data for the 2009 plantings show that even in Spain the overall area under

four gm crops in europe

continued

cultivation dropped by over 4% between 2008 and 2009 (Spain, 2009). Similarly, official data from Romania shows a reduction of almost 50% in the area of GMO crops (INFOMG, 2010).

GM maize cultivation in the Czech Republic fell from 8,380 ha in 2008 to 5,745 ha as of July 2009. The number of cultivations fell from 171 to 100 (Greenpeace, 2010). In Slovakia, the area of MON810 also fell from 2008. 1,930.87 ha were cultivated in 2008 and 875 ha in 2009, a drop of more than 50%.

4.2 public opinion

A majority of the EU public remains opposed to the use of GMOs in food and farming. The latest Eurobarometer poll (European Commission, 2008) published in 2008 showed that 58% of EU citizens opposed GMOs. Earlier surveys also found that GMOs used in food and farming were more strongly opposed than other applications of biotechnology (Gaskill *G et al*, 2006). Ukrainian consumers were polled in 2009, and more than 93% supported a ban on GMO imports (Unian, 2009).

This overwhelmingly negative response to GMOs has also prompted many Member States to try and keep the locations of GM test sites secret. In 2009 Europe's highest court, the European Court of Justice, ruled that EU member states cannot cover up the location of sites where genetically modified organisms have been released, even if they fear that the information could provoke public disorder (GM-Free Ireland, 2009).

4.3 gmo-free regions

This deeply held opposition to GMOs has also been demonstrated across the whole of Europe by the official declaration of GMO-free zones in 28 countries: 169 regions, 123 sub-regional bodies and 4,587 local government organizations have signed up in 28 different countries (GMO-free regions.org, 2010). Individual consumers and farmers are also joining the growing movement to oppose GMOs in Europe.

4.4 gm-free labels for non-gm animal feed a big hit

Current EU legislation only requires the labelling of GM animal feed: animals reared on GM animal feed do not have to be identified. This has led to consumers unknowingly consuming animals fed on a GM diet. But major companies are now recognizing that there is a market for non-GM fed animals - in Germany legislation allows for products produced from animals fed non-GM feed to be labelled 'without biotechnology' and major companies are adopting this approach, including supermarket chain Lidl, the major dairy company Campina and chicken meat producer Gebrüder Stolle. Similar 'without GMO' labelling legislation is planned in France and Ireland (ISSA, 2009).

4.5 gmos crops in the pipeline

The vast majority of GM applications in the EU are for pesticide-promoting crop varieties. These are GM applications that are not designed to increase yields or reduce resource use. Of the 23 applications for GM cultivation in the EU, 21 are also for herbicide tolerance (HT) or insect resistance (IR) traits (GMO Database, 2010).

Outstanding applications for the cultivation of GMOs in the EU, including the renewal of the application for MON810, are shown in Table 3.

TABLE 3

OUTSTANDING EU GM CROP APPLICATIONS

CROP	APPLICATIONS	TRAIT
Cotton	2	HT, IR
Flowers	2	Altered color, longer shelf life
Maize	14	HT, IR
Oilseed rape	2	HT
Potatoes	2	Increased starch content
Soybeans	1	HT
Sugarbeet	2	HT

Source: GMO Database (2010).

There are specific concerns about the safety of the most advanced application for a starch-altered potato, 'Amflora,' which is intended to facilitate the production of industrial non-food starch. These concerns had prevented its approval for a long time. The presence of antibiotic resistant marker (ARM) genes, which are restricted under EU regulations, has meant the safety of the GM potatoes, now owned by BASF, was reviewed again by the European Food Safety Agency (EFSA) and the European Medicines Agency in 2009: EFSA was unable to reach a unanimous opinion on the safety of the ARM genes (EFSA, 2009). However, in March 2010, Europe's new health and consumer commissioner, John Dalli, gave the go ahead for genetically modified potatoes to be grown in Europe (FoEE, 2010).

There are also many applications for importing GMO crops to be processed for food and feed. Of the 119 GM crops pending approval for import to the EU, more than 80% are herbicide tolerating or insect resistant traits or combinations of the two. All but one of the remaining applications is for non-food crops such as GM flowers (GMO Database, 2010).

One maize application (MON87460) is for a drought tolerance trait that even Monsanto admits may not be effective in producing a viable yield in very dry conditions (GMO Database, 2010a).

“Under water-limited conditions, grain yield loss is reduced compared to conventional maize. However, like conventional maize, MON 87460 is still subject to yield loss under water-limited conditions, particularly during flowering and grainfill periods when maize yield potential is most sensitive to stress, by disrupting kernel development. Under severe water deficit, maize grain yield for MON 87460, as well as conventional maize, can be reduced to zero.”

Syngenta SAS has also applied for a maize that is genetically modified to produce alpha amylase enzyme, for the production of bio-ethanol in the EU (GMO Compass, 2009).

Analysis of the available data therefore shows that despite a huge public relations effort on the part of the GM industry there are still no GM crops to increase yields or cope with climate change in the pipeline. This follows a long history of unfulfilled promises from GM proponents.⁶

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Intensively farmed monocrop.

⁶ For more information on this see ‘Promises, promises – the claims of the biotechnology industry’ chapter.

five gmos in the southern cone

gmos in the southern cone

5.1 introduction

The Southern Cone of America⁵ is a region of prime importance for global food production, and has been specifically targeted by transnational agribusiness for the commercial production of GM crops. Along with the US, the Southern Cone is now responsible for more than 80% of the total area planted with GMOs worldwide.

Genetically modified organisms are now a key element of agribusiness development, particularly in this region. Technological 'packages' have been developed, based on the use of agricultural machinery and genetically modified seeds and biocides, which enable a quick return on invested capital. These packages require little manual labor and externalize associated environmental and social costs. As a result, agribusiness has become particularly attractive to investors and speculative capital. In recent years there has been a significant flow of capital from various financial sectors towards GM agriculture.

However, the rapid advance of agribusiness and genetic engineering in the Southern Cone has brought with it serious social and environmental impacts that are not being adequately dealt with by governments. Booming agribusiness is displacing peasant and indigenous communities; pushing the agricultural frontier deeper into the forests; increasing pollution and health problems because of the increased use of biocides; accelerating the erosion of natural resources; and destroying peoples' knowledge and food sovereignty.⁷

As a result of all this, farmers and social organizations are actively resisting the advance of agribusiness. In particular, soy has seen spectacular growth in the last decade, and battles over soy expansion illustrate the social tensions created by the rapid concentration of land, wealth and power. In Paraguay, for example, displacements and the indiscriminate use of herbicides on soy plantations have led to serious conflicts and the murder of Paraguayan peasants (Zibechi, 2005). In Brazil, a demonstration organized by the landless workers' movement, Movimento dos Trabalhadores Rurais sem Terra (MST), against an experimental area managed by Syngenta, ended with a peasant being shot dead by security guards hired by the company (La Jornada, 2007). In Uruguay, the expansion of soy agribusiness has displaced family agriculture, because the increase in agribusiness has increased land rental rates; and thus the main

organization of family farmers (Comisión Nacional de Fomento Rural) has asked the Uruguayan government to limit the expansion of agribusiness in order to prevent the complete disappearance of family farming (CNFR, 2009).

Agribusiness interests in the region also exert considerable influence and can be difficult for governments to resist. In Bolivia, for example, one of the main leaders of the Media Luna (the richest region of the country), and President of the Pro-Santa Cruz Civic Committee, Branco Marinkovic, is also one of the main soy producers in the region (El Deber, 2007). This Committee promoted the creation of an autonomist movement in defense of the interests of the powerful local elite and opposed to recognizing the rights of the original peoples. This posed a serious problem for the administration of Bolivian President Evo Morales (Bolpress, 2008) (TeleSUR, 2010), and several indigenous people were murdered as a consequence of this conflict (BIC, 2008).

Similarly there was a sharp conflict between the 'campo' (the countryside) and the Argentinean government in 2008, when soy industrialists opposed the government's restrictions on commodity exports (Página 12, 2008) (Programa de las Américas, 2009).

5.2 the advance of gm crops in the southern cone

At present, GM crops occupy around 37 million ha in the Southern Cone, which represents one third of the surface area dedicated to GM crops around the world. The main GM crop is soy, but GM maize and cotton are also being cultivated. Apart from the United States, Argentina and Brazil are the world's two main producers of GM crops. Within the region, Argentina has the largest surface area of GM crops (19 million ha), followed by Brazil (with 14.5 million ha) (See Table 4).

Agribusiness's intense drive to find countries willing to cultivate genetically engineered crops on a commercial scale has given a new momentum to the expansion of intensive industrial agriculture in the Southern Cone region, undoing much that had previously been done to develop agri-ecological farming in the area. This is most marked in terms of the expansion of GM soy.

In the season 2008/2009 some 21.7 million ha of soybean were sown in Brazil, and for 2009/2010 around 23 million ha of soy are expected to be sown, generating a record crop of 64 million tons (CONAB, 2009). According to estimates from the private sector, around 60% of the area (around 13 million ha) is genetically modified Roundup Ready (RR) soy (EU, 2009; RPC, 2009/2010).

⁷ For a full definition of food sovereignty please see page 32.

TABLE 4

SURFACE AREA OF GM CROPS IN THOUSANDS OF HA (SEASON 2008/09)

COUNTRIES	SOY	CORN	COTTON	CANOLA /OILSEED RAPE	TOTAL
Argentina	16,800	1,910	280	-	18,990
Brazil	13,000	1,300	250	-	14,550
Paraguay	2,000	-	-	-	2,000
Uruguay	580	72	-	-	652
Bolivia	650	-	-	-	650
Chile*	0.2	11.6	-	4.1	15.9

Sources: The data for this table was collected from several sources because there is no official data available corresponding to each country. Argentina: MAGyP Argentina, ArgenBio; Brazil: CONAB, Report from an EU mission in Brazil, RPC, CIB; Paraguay: MAG; Uruguay: MGAP; Bolivia: ANAPO; Chile: SAG. * For Chile the data relates to surface dedicated to seed plots.

In Argentina, soy crops covered around 18 million ha (equivalent to more than 75% of the area occupied by summer crops) but as a result of the drought of the summer 2008/2009, only 16.8 million (MAGyP, 2009) were harvested. Almost 100% of this was RR soy (ArgenBio, 2010).

In Paraguay, according to the National Agricultural Survey (CNA, using its Spanish acronym) (MAG, 2008), 2.5 million ha of soy were sown in 2008/2009 (nearly 60% of the total agricultural area of the country) of which 80% was RR soy (RAP-AL, 2010).

In Uruguay, soy occupied 580,000 ha in the season 2008/2009 representing 75% of the surface sown with summer crops (MGAP-DIEA, 2009), and nearly 100% of this was RR soy. In Bolivia, 50% of the agricultural land (around 940,000 ha) was sown with soy in 2009; and 70% of this, according to ANAPO, was RR soy (IFPRI).

As a whole, soy crops in the region occupied 42.5 million ha (425,000 km²), of which 33 million were RR soy; the overall production of soybean was 97 million tons.

In relation to corn, some 14 million ha were sown in Brazil in the 2008/2009 season (IFPRI). The Council on Information on Biotechnologies (CIB), an organization that promotes GM technology in Brazil, estimates that 1.3 million ha of this was GM corn (CIB, 2009). In Argentina, for the same season, nearly 3.5 million ha was sown with corn although only 2.3 million (CIB, 2009) was actually harvested due to drought. Of this, 83% was GM corn, according to ArgenBio (CIB, 2009), an organization that brings together GM seed multinationals operating in Argentina. In Uruguay, although there is no data for the total area sown with GM corn, 82% of the seed imported in 2008 was

GM (INASE, 2009). It is thus possible to calculate that around 80% of the area cultivated in Uruguay in the 2008/2009 season (over a total sown area of 87,500 ha (MGAP-DIEA, 2009)) was planted with GM corn.

For cotton, Brazil planted 840,000 ha in 2008/2009 (CONAB, 2009), of which 250,000 ha was GM cotton according to CIB (CIB, 2009). In Argentina, 94% (ArgenBio, 2010) of the total of almost 300,000 ha of cotton (MAGyP, 2009) was sown with GM seeds.

In Chile, GM seeds are only allowed to be used for the production of seeds for export (at present they are discussing a future biosafety law and whether or not they should authorize the commercial release of GMOs). The main GM crop grown is corn, at 11,850 ha, followed by canola at 4,054 ha, and soy at 204 ha (SAG, 2010).

5.3 the commercial release of gmOs in the southern cone – questionable authorizations

In the Southern Cone, the introduction of genetically modified crops started in 1996, when Argentina and Uruguay authorized the cultivation of Monsanto RR soy. Neither country conducted an environmental impact study, and no assessments were made of the likely social and economic impacts.

GM soy was then transferred illegally from Argentina and Uruguay, into Brazil, Paraguay and Bolivia. Seed companies subsequently chose to develop and promote their products in these countries on the basis of a *fait accompli* strategy – it is already there, and it is unalterable. In Brazil, two other Monsanto GM products (AS-PTA, 2009), Bollgard cotton and GA21 corn also entered the country illegally (in 2004 and 2005 respectively).

In Paraguay, the NGO Alter Vida estimates that around 8,000 ha are currently being cultivated with GM cotton, even though the approval process has not passed the evaluation stage yet (RAP-AL, 2010). Similarly, most of the GM cotton sown in Argentina seems to be a cultivar with two stacked GM traits that has not yet been authorized for planting (RIAN, 2009). The governments have responded to this strategy with a policy that essentially enshrines impunity. Instead of issuing and enforcing sanctions to control the illegal introduction of these crops in their countries, they have adapted their country's regulations to allow for GM crops. In Brazil they have even used the fact that they are already being grown as an argument for authorizing GM crops (RIAN, 2009).

During 2009, several new GM varieties were approved in the region. Three GM varieties of cotton, five of corn and one of soy (CTNBio, 2009) were released in Brazil. The latter is the first GM variety released that was also developed in Brazil, as a result of an agreement between BASF and Embrapa Soja (a part-public

five gmos in the southern cone

continued

Brazilian firm dedicated to agricultural research). This GM variety is tolerant to herbicides of the imidazolinone group and is presented as an alternative to RR soy to fight those weeds that have already developed a resistance to glyphosate (BLT, 2009).

In Argentina, a new GM cotton variety has also been released and several licenses have been granted to produce GM corn seeds for export (even though these do not yet have a commercial release approval) on the condition that they have been approved at the destination country (CONABIA, 2009). In 2008 (no update is available for 2009), 49 licenses were granted to produce GM corn seeds, including 13 to Monsanto and 8 to Syngenta. 180 experimental releases were also authorized

including for soy, maize, wheat, sugar cane, cotton, rice, safflower, orange, potato and alfalfa (CONABIA, 2009a).

In Uruguay, after lifting the moratorium on new GM releases (in place from January 2007 to July 2008), the evaluation of five new GM traits in maize was approved; and the production of two new types of GM soy was also authorized, although only for export (which conveniently allows producers to skip the two-year evaluation process required for any GM crop to be commercially released within the country) (GNBio, 2009).

All new GM releases consist of GM traits related to herbicide tolerance (glyphosate or glufosinate ammonium) and/or lepidoptera resistance, either individually or stacked together.

TABLE 5

AUTHORIZATIONS GRANTED TO GM CROPS AND COMMERCIAL RELEASE YEAR PER COUNTRY

SPECIES	DEVELOPMENT	APPLICANT	TRAIT*	ARGENTINA	BRAZIL	URUGUAY	PARAGUAY	BOLIVIA
Soy	GTS 40-3-2	Monsanto	TH(G)	1996	(1998)** 2005	1996	2004	2005
Soy	BPS-CV127-9	BASF-Embrapa	TH(I)		2009			
Maize	176	Ciba-Geigy (Syngenta)	RL	1998				
Maize	T25	Bayer	TH(GA)	1998	2007			
Maize	MON 810	Monsanto	RL	1998	2007	2003		
Maize	Bt11	Syngenta	RL+TH(GA)	2001	2007	2004		
Maize	NK603	Monsanto	TH(G)	2004	2008			
Maize	TC 1507	Dow - Pionner	RL+TH(GA)	2005	2008			
Maize	GA21	Syngenta	TH(G)	2005	2008			
Maize	MIR 162	Syngenta	RL		2009			
Maize	MON 810 x NK603	Monsanto	RL x TH(G)	2007	2009			
Maize	Bt11 x GA21	Syngenta	RL+TH(GA)xTH(G)		2009			
Maize	TC 1507 x NK603	Dow - Pionner	RL+TH(GA)x H(G)	2008	2009			
Maize	MON 89034	Monsanto	RL		2009			
Cotton	MON 531	Monsanto	RL	1998	2005			
Cotton	LLCotton25	Bayer	TH(GA)		2008			
Cotton	MON1445	Monsanto	TH(G)	2001	2008			
Cotton	281-24-236/3006-210-23	Dow	RL+TH(GA)		2009			
Cotton	MON 15985	Monsanto	RL		2009			
Cotton	MON531 x MON1445	Monsanto	RL x TH(G)	2009	2009			

Sources: (CTNBio, 2009) (CONABIA, 2009) (GNBio, 2009) (Observatorio IICA, 2009) (Pardo, M y Gudynas, E. 2005)

* TH: Tolerance to herbicide, (G): Glyphosate, (I): Imidazolinonas, (GA): Glufosinate Ammonium. RL: Resistance to Lepidoptera (The table does not show those developments currently being assessed, or authorized only for seed production for export.)

** GTS 40-3-2 (RR) soy in Brazil was approved in 1998 but suspended by judicial decision favorable to the Brazilian Institute for the Defense of Consumers; in 2005, it was authorized as a consequence of the Biosafety law being approved (Fernandes, 2009).

5.4 increased use of pesticides

The main environmental impacts related to the introduction of agri-biotechnology are associated with the expansion of soy monocultures. Each hectare cultivated with soy requires the use of approximately 4 liters of biocide and in the case of RR soy, around 10 liters of glyphosate. In the Southern Cone, during the last season, around 200 million liters of biocides were used on soy crops (including the highly toxic organochlorine endosulfan, which is banned in many countries around the world); and 350 million liters of glyphosate were applied to the area cultivated with GM soy. This has had serious consequences on both the environment and human health, particularly for rural populations. The death of Silvino Talavera in 2003, a Paraguayan child who died after coming into contact with pesticides being used on GM soy close to his house, is emblematic of this. There have been many similar cases of pesticide poisoning, particularly in Paraguay (Palau, 2004).

As discussed elsewhere in this report, the massive application of glyphosate that has taken place is also beginning to show its effects in the development of glyphosate resistance in several weed species. In Argentina these include *Hybanthus parviflorus* (Violetilla), *Parietaria debilis* (Yerba Fresca), *Viola arvensis* (Violeta Silvestre), *Petunia axillaris* (Petunia), *Verbena litoralis* (Verbena), *Commelina erecta* (Flor de Santa Lucía), *Convolvulus arvensis* (Corrihuella, Slender dayflower), *Ipomoea purpurea* (Bejuco, Morning glory), *Iresine difusa* (Iresine) and recently the *Sorghum halepense* (Sorgo de alepo, Johnsongrass) (BSC, 2009). The latter is a particularly serious concern as it is especially difficult to control.

In Brazil, Embrapa researchers have also reported cases of glyphosate resistance in nine species, four of which are weeds that may cause serious problems to crops: *Conyza bonariensis*, *Conyza Canadensis* (buva, Canadian horseweed), *Lolium multiflorum* (azevem, Italian Ryegrass), and *Euphorbia heterophylla* (milkweed) (Cerdeira *et al*, 2007). The resistant Canadian horseweed has become a particularly severe problem in Brazil since these resistant plants have spread rapidly (Gazeta do Povo, 2009). Another widely distributed species in Brazil and Paraguay, *Digitaria insularis*, commonly known as sourgrass, is also reported to have developed herbicide resistance (Weedscience.org, 2010). Ironically, the biotech industry proposes to resolve this problem by developing yet more GM soybean varieties, that are resistant to other herbicides. For example, the CNTBio of Brazil is considering the authorization of a GM soy variety that is resistant to 2,4-D, a herbicide that is even more toxic than glyphosate, and forbidden in many countries (BLT, 2009b).

During 2009, another controversial issue arose following investigations into the impacts of glyphosate on embryo development. Andres Carrasco, an embryology professor of the School of Medicine of the University of Buenos Aires (also the main researcher of the National Council of Scientific and Technical Research (CONICET) and Director of the Molecular Embryology Laboratory) confirmed the lethal effect of glyphosate on amphibian embryos. As a consequence of an article in an Argentinean newspaper, where the scientist released the conclusions of his study, the Association of Environmental Lawyers filed a special injunction claim with the Supreme Court of Law, requesting a ban on the use and sale of glyphosate until its effects on health and the environment were assessed. Some days later, the Ministry of Defense also took the unusual step of forbidding the cultivation of soy on Ministry lands. The corporations and agribusiness lobby associations, along with others in the media and politics, were outraged and a formidable campaign was launched to defend agrichemicals and discredit the critics (Página12, 2009). The Chamber of Agricultural Health and Fertilizers (CASAFA, which is the lobby association for agrichemical companies in Argentina and also has two representatives on CONABIA, the Argentinean Biotechnology authority) even sent its lawyers to the laboratory where Carrasco worked in order to demand a copy of the scientific report. Months later, an interdisciplinary report by CONICET (a government body focusing on the promotion of science and technology) concluded that there was insufficient data available in Argentina on the effects of glyphosate on human health. In a further article, Carrasco branded the document “institutionally outrageous” because of its reference and links to studies commissioned by Monsanto. The debate goes on, but so does the use of glyphosate (Newsweek Argentina, 2009).



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Crop duster spraying fields.

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continued

5.5 land grabbing and deforestation

The impact that the expansion of soy production is having on forests in the Southern Cone is also extreme. In Argentina, for example, 200,000 ha of native forest disappear every year as a direct consequence of the advance of the agricultural frontier, and this is mainly driven by the expansion of soybean monocultures (Dirección Nacional de Ordenamiento Ambiental y Conservación de la Biodiversidad, 2008).

Thousands of farmers are also evicted violently from their lands. The MOCASE (Peasant Movement of Santiago del Estero) and MNCI (National Indigenous-Peasant Movement), members of La Via Campesina Argentina, are continuously denouncing the persecution suffered by peasants when they resist eviction by force. In the northwest region of the country, the peasant and indigenous communities' struggle against these displacements and forest clearance has even been criminalized: an example is the Cacique Cavana of the Wichi Community in the basin of the river Itiyuro (in the province of Salta), who has been accused in more than sixty criminal lawsuits. The situation is similar in Paraguay where several peasants have been murdered for resisting the advance of soy monocultures.

5.6 contamination

In the case of maize, genetic contamination from GM releases has also become a serious concern. During 2009, studies carried out in Brazil (Silva, 2009), Chile (FSS, 2010) and Uruguay (P.Galeano *et al.*, 2009) showed the presence of genetically modified genes in conventional plants. These studies show that the isolation measures established in the various national regulations are not enough to avoid contamination by out-crossed pollination. The concept of 'regulated co-existence' between GM production and conventional crops is increasingly used in biosafety policies, but these studies show that co-existence is not possible in the case of maize. They also demonstrate the pervasive character of GM technologies.

5.7 stakeholders

Agribusiness corporations have established a series of organizations in the Southern Cone dedicated to political lobbying and influencing public opinion. CropLife is a network of these organizations, and includes business chambers dealing with agri-biotechnology (CropLife, 2010). This network and others, together with ISAAA and organizations such as ArgenBio and the Council of Information on Biotechnologies of Brazil – which have been founded and are wholly or partly funded by biotechnology corporations – are the main source of information for the Technical Commissions in charge of risk assessments, research and development centers, and the media. The aims of ArgenBio make this point clear:

"ArgenBio was created with the mission of disseminating information on biotechnology, contributing to its understanding through education and promoting its development. ArgenBio arises from the commitment undertaken by its founding members to respond to the demand for clear and transparent information about biotechnology and its applications, its benefits and its safety. To such end, our priority is to develop activities in the following areas: qualification and training, dissemination, education, and general information. Thus, ArgenBio aims at reaching the following public audiences, providing them with adequate information according to their respective interests and needs: professionals and teachers, media, and the general public." (Argenbio, 2010b)

The founders of ArgenBio are: Bayer, Dow, Monsanto, Nidera, Syngenta and Pioneer.

On the other side, we find social movements and peasants' organizations struggling to challenge the dominance of this powerful industry. These organizations include peasant movements, umbrella organizations like La Via Campesina, the network for a GMO-free Latin America (*Red por una America Latina libre de Transgénicos*), and academic associations like SOCLA (the Latin American Scientific Society of Agroecology). These organizations need to build and maintain alliances representing popular sectors, to challenge the advance of agribusiness and biotechnology effectively.

Following the 6th Brazilian Congress on Agri-ecology and the 2nd Latin American Congress on Agro-ecology held in Curitiba in November of 2009, more than 3,800 participants signed the Agro-ecological Letter of Curitiba (Carta agro-ecológica de Curitiba) 2009. This letter sums up the threats that agribusiness and biotechnology pose to society, our natural resources and the environment in general, as the following translated extract demonstrates:

"It is essential for human kind to keep the centers of origin of cultivated species free from GMOs, and to prevent the patenting of genetic resources thereby allowing us to freely exchange seeds;

We are against agricultural practices, technologies, public policies and agricultural and food business corporations that threaten environmental protection, increase socio-economic inequity, and endanger food safety and food sovereignty, human health and life; especially with respect to genetically modified organisms and agritoxics." (Carta Agroecológica de Curitiba 2009)

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Cattle Ranch in Mexico

six the new promise: gm crops and climate change

the new promise: gm crops and climate change

Even though claims that genetically modified (GM) crops can solve hunger and poverty remain unproven, a new claim has recently emerged: that GM crops will be one of the solutions to combating climate change.

This claim is based on a range of arguments, including a rehashing of older declarations that GM crops reduce pesticide use and increase yields, meaning that they will be useful in both mitigating and adapting to climate change. An additional new argument is that GM crops will reduce the loss of carbon from soil by reducing tillage. It is also being claimed that new drought-resistance crops are about to be commercialized. Biotech companies are lobbying hard (EuropaBio 2008) at the UN's climate change negotiations, for GM crops and industrial farming methods, which are responsible for up to 50% of global emissions of nitrous oxide, to be recognized as mitigation techniques in agriculture (Europa Bio 2008).

As a result, governments and private funders such as the Gates Foundation are ramping up their investments in GM research. In the UK, for example, the government spent £49 million on biotechnology in 2006/2007, compared to just £1.6 million on organic farming (Friends of the Earth, 2007). In October 2009, the Gates Foundation announced a further US\$120 million grant for agriculture in Africa. At the press launch Bill Gates said *"Biotechnology has a critical role to play in increasing agricultural productivity, particularly in light of climate change."* (America.gov 2009)

6.1 the solution is not more of the same

GM crops have been developed as part of the intensive model of agriculture that has dominated farming over the last 60 years. Intensive crop and livestock farming methods require large inputs of oil, artificial fertilizers, pesticides and the use of hybrid seeds. Collectively these are major contributors to climate change, since they lead to increases in greenhouse gas emissions, reductions in soil carbon, soil erosion and habitat destruction. The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD), which has an intergovernmental governance structure, has concluded that "business as usual is not an option" (IAASTD, 2008) and that farming practices will have to change radically to meet the challenges of climate change. These will include feeding a growing population, protecting and restoring biodiversity and ecosystems services, and producing fuel and raw materials for industry.

The GM industry has also failed to gain acceptance for GM plant varieties as food crops in important markets especially in Europe, Africa, Japan and, most recently, India (MOEF, 2009). This is primarily due to public and political concern about the potential socio-economic, environmental and health impacts of GM crops (Mmegi, 2009; Biosafety Africa, 2009; Friends of the Earth Europe, 2008).

Many of the industry's claims about GM technology turn out to be exaggerations or entirely premature. In addition, the model of GM farming, like other forms of intensive agriculture, is reliant on highly expensive technology and energy-intensive inputs. To rely on such uncertain claims would be very foolish given the urgent need to tackle the causes and effects of climate change.

GM is a false solution to climate change. It is also highly expensive to develop and thus suppresses the development of other approaches. Meanwhile the value of local agricultural knowledge and agro-ecology continues to be recognized in recent reports (APPG, 2010; UNEP, 2008; IAASTD, 2008). But, agro-ecological alternatives receive little attention and even less funding from governments and private charities such as that of Bill Gates, when compared to investments in GM and biotechnology (GM Freeze, 2008).

6.2 examining the evidence on gm and climate change

claim # 1: gm farming increases carbon retention in soils

'Soil carbon' refers to the organic matter present in most soils, which can be released as carbon dioxide if soils are disturbed; such disturbances are common in industrial agriculture and logging, and contribute to climate change. A technique known as 'conservation tillage', which leaves some of the crop residues or stubble on the surface rather than plowing it back into the ground, is used to minimize the disturbance of the soil and soil erosion.

The claim that GM technology can increase the relative retention of carbon stored in soil comes from the use of such zero or minimum tillage cultivation techniques with GM crops. However, 'conservation tillage' was developed well before the first GM crops appeared and is in no way specific to GM crops. It was originally intended to enhance soil and water conservation.

Furthermore, the introduction of GM herbicide tolerant crops (GMHT) is undermining the sustainability of these earlier conservation tillage systems, by increasing the quantity of herbicides used and because of soil compaction by repeated use

of heavy machinery, for example in the central Pampas region of Paraguay (Gerster *et al*, 2008). Indeed some reports suggest that a reduction in overall emissions of greenhouse gases from zero tillage systems is not proven (Paul H *et al*, 2009) because of increased carbon dioxide and nitrous oxide emissions. In addition, recent studies suggest that 'no-till', one particular form of conservation tillage, has environmental benefits such as reducing soil erosion, but may not sequester more carbon than conventional tillage (plowing) (UCS, 2009).

Importantly, the overall claim is also based on the promise that GM herbicide tolerant crops will lead to a reduction in the quantity of herbicide applied because of the use of just one herbicide, the elimination of pre-sowing applications of herbicides, and fewer applications on the growing crop. However, after more than a decade cultivating GMHT in North and South America, evidence from both governmental agencies and academics confirms that the crops actually increase herbicide use. A recent review found that in the 13 years since GMHT crops were introduced in the US, the amount of herbicide applied had increased by around 144,000 tonnes (Benbrook C, 2009).

It is also notable that the claims made about GM crops' relative ability to sequester carbon in soil are based on comparisons with other forms of intensive agricultural production. They tend to overlook agricultural practices based on agro-ecological principles in which carbon rich materials, such as manure and compost, are systematically returned to the soil to improve it. There are also other types of conservation tillage, including methods suitable for organic farming systems, in which the use of chemical herbicides is not permitted.

In fact many recent studies demonstrate that a number of agronomic practices employed in integrated agricultural systems have great potential to build-up soil carbon content over time. These techniques combine crop rotation, recycling organic materials and low or no inputs of pesticides, herbicides, and industrial fertilizers. For example, studies that compare carbon accumulation in organic (plowed) and conventional (plowed) systems demonstrate that organic systems sequester more carbon than conventional chemical-intensive systems (Drinkwater, 1998; Pimental, 2005; Wander, 2006).

Systems that integrate livestock and crops, employ perennial pastures, and adopt many of the practices used in organic production (eg long crop rotations, leguminous crops and cover crops, and manure produced by livestock as fertilizer) also have potential for improved greenhouse gas balance, as well as reduced pollution (Smith P. *et al*, 2007).

In spite of these concerns though, GM no-till is currently being considered for carbon finance funding by the UNFCCC climate change negotiations (Paul H. *et al*, 2008).

claim # 2: gm crops reduce greenhouse gas emissions from farm operations

This claim is based on the idea that herbicide tolerant GM crops require fewer herbicide applications, thus saving fuel by reducing the number of tractor passes across the field (PG Economics, 2009). This claim is closely connected to that of zero tillage as the two systems go hand in hand. These promises initially encouraged farmers to buy GMHT seeds: they expected improved weed control and reduced fuel and labor costs. However, after a brief 'honeymoon period' when GMHT crops were first introduced in 1996, problems began to emerge.

gmht crops and herbicide resistant weeds In the US, Argentina and Brazil, where the majority GMHT crops are grown, the promise of reduced herbicide use has been seriously undermined by the development of weeds with strong resistance to herbicides such as Roundup (GM Freeze, 2010). This means other or additional chemical herbicides have to be used.

The majority of GM crops have been designed to be tolerant of either Monsanto's Roundup (glyphosate) or Bayer's Liberty (glufosinate ammonium). Crops tolerant to Roundup (known as RR or Roundup Ready) are the most prevalent in all the GM crop-growing countries. In the US, for example, 100% of the GM soya produced is RR, GM maize is about 95% RR and GM cotton about 97% RR. In Brazil and Argentina 100% of the GM soya crops has been Roundup Ready over the last 12 years.

The evolution of weeds that are resistant to Roundup has clearly accelerated since the introduction of GMHT crops, undermining the whole zero tillage approach. In Argentina, one of the countries used as the perfect example of no-till farming, the spread of glyphosate resistant (GR) Johnsongrass (*Sorghum halepense*) has been very rapid. By 2007, all Argentinean provinces growing GM soya were infested with it, and it is known to have covered 10,000 ha in Northern Argentina, although throughout the country the area may be as high as 100,000 ha. It has been observed that "...the evolution of glyphosate-resistance in *S. halepense* is a major threat to glyphosate-resistant soybean productivity in northern fields of Argentina." (Vila Auid *et al*, 2008)

The impact of resistance is also being felt in the US where an analysis of pesticide usage based on official data showed that GM crops have actually resulted in a net increase in pesticide use – compared with pre-GM figures, an additional 0.11kg of pesticide was applied per acre in 2008 (Benbrook C, 2008). GM crops are generally pushing pesticide use upward in the US. In 2008, for example, GM crop acres required over 26% more pesticide per acre in the US than conventional varieties (Benbrook C, 2008). This trend is projected to continue as a result of the rapid spread of glyphosate-resistant weeds.

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Perhaps unsurprisingly, the agro-chemical industry's solution to weed resistance is to use yet more herbicide, by recommending the use of Roundup in combination with other herbicides with higher toxicity such as 2,4 D (2,4-Dichlorophenoxyacetic acid, a component of Agent Orange used during the Vietnam War). GMHT crops with several HT traits relating to different herbicides are also being developed, so that a range of products can be used on glyphosate-resistant weeds. But this will only serve to increase dependency on fossil-fuel based chemical weed control (Monsanto, 2006).

In addition, farmers are also resorting to tillage in order to control weeds, which again undermines the no-till promotion of GM crops.

In conclusion, claims that GMHT crops would lead to lower labor costs and reduced herbicide applications, and that they are climate friendly because of reduced tillage, are increasingly found to be wanting.

gmht crops damage soils Zero tillage also depends on the use of heavy equipment and tractors to carry out field operations, but prolonged use can cause soil compaction. This is a well-documented problem common to all forms of cultivation that rely on heavy machinery for field operations (Pen State University, 1996). The use of zero tillage on monocultures of the same crop year after year – which is the basis of GMHT crop cultivation in North and Latin America – is a sure way to develop soil compaction. Compaction can reduce root penetration and water logging and can eventually reduce yields. Furthermore, any remedial action is also like to depend on the use of fossil fuel intensive machinery.

Overall, some of the energy saved from reducing the number of field operations is immediately lost by using more power per operation. Alternative approaches to crop production based on agro-ecological principles use nitrogen fixing plants, composts and manures together with crop rotation. This builds soil fertility, including by increasing the organic matter/carbon in the soil and increasing its moisture-holding capacity. These improvements in soil structure help reduce soil erosion and increase penetration of rainfall. Biodiversity also increases over time, which improves nutrient cycling and increases numbers of pest predators.

claim # 3: gm crops will feed us in a warming world

gm crops do not produce higher yields It is frequently claimed that GM crops produce higher yields than conventional crops, meaning that more food should be produced from the same area of land. The argument is that this would alleviate the need for increased land for agriculture, which currently leads to the destruction of forests and other carbon-rich ecosystems. But none of the GM crops so far developed for commercial cultivation has been yield enhancing, and there is no evidence to support this claim. Rather than increasing yield, the focus has been on agronomic traits and over 99% of commercial GM crops are modified to create herbicide tolerance or insect resistance (or both) (ISAAA, 2009).

The largest and most comprehensive assessment of agricultural science, the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) examined the evidence for GM and found no definite evidence that GM crops were yield-enhancing:

"Assessment of modern biotechnology is lagging behind development; information can be anecdotal and contradictory, and uncertainty on benefits and harms is unavoidable. There is a wide range of perspectives on the environmental, human health and economic risks and benefits of modern biotechnology, many of which are as yet unknown....The application of modern biotechnology outside containment, such as the use of genetically modified (GM) crops is much more contentious. For example, data based on some years and some GM crops indicate highly variable 10-33% yield gains in some places and yield declines in others." (IAASTD, 2008)

Yield is a complex phenomenon that depends on numerous factors, including weather, the availability of irrigation and fertilizers, soil quality, farmers' management skills, and levels of pest infestation. Genetic improvements achieved through conventional (ie non-biotechnological) breeding are also important. Indeed, traditional plant breeding has continued since GM crops were first introduced and hence the steady rise in overall yields since 1996 can be attributed to this general trend, which started in the 1930s.

A recently published review, which closely evaluated the overall effect that genetic engineering has had on crop yields in relation to other agricultural technologies, observes that GM technology has had little or no overall impacts on crop yields:

"Overall, corn and soybean yields have risen substantially over the last 15 years, but largely not as a result of the GE traits. Most of the gains are due to traditional breeding or improvement of other agricultural practices." (Gurian-Sherman, 2009)

Several other studies have reported similar findings (Jost P *et al*, 2008; Elmore R *et al*, 2001; Ma *et al*, 2005). Studies also show

Left: Crop spraying.
Right: Corn.



that Roundup Ready soya suffers from 'yield drag' with on average 5-10% lower yields than conventional soya, as well as reduced uptake of essential nutrients (Elmore *et al*, 2001).

most gm crops are not produced for food As explained previously, the overall contribution of GM crops to global food supply remains small in comparison to other crops bred in a conventional manner. There is no commercial production of most of the world's staple crops – wheat, barley, oats, potatoes, rice, sorghum, cassava, and millet (although in 2009 China did grant safety certificates for small-scale field trials of GM rice and GM maize). With the exceptions of small areas of papaya and squashes in the USA and tomatoes and sweet pepper in China, no GM fruit and vegetables have been developed to the point of commercial cultivation either.

GM production is largely confined to four crops: soya, maize, oilseed rape and cotton are grown on over 99% of the total area under GM cultivation. And 95% of the area grown is in just six countries: the US, Brazil, Argentina, Canada, China and India. In 2009 industry sources (ISAAA, 2010) reported that 134 million ha of GM crops were being grown in the world: this amounts to just 2.7% of farmed land (GM Freeze, 2010). The proportion of the world's farmers actively growing GM crops – 14 million according to the industry – is around 1.1% of the total 1.3 billion farmers (ISAAA, 2010). It is important that the claims being made for GM crops' ability to contribute to alleviating the impacts of climate change-induced hunger are assessed in the light of this data.

In addition, between 66% and 90% (DSC, 2008) of all soya production is fed to animals, mainly in very inefficient intensive production systems (the ratio of plant protein needed to produce one unit of animal protein varies between 5 and 9 depending on the system being employed). The GM crop industry is thus contributing directly to industrial livestock production, which is also a major producer of greenhouse gases through land clearance (6%) and methane emissions (6%) (Garnett, 2007).

'marginal land' cannot be used for gm miracle crops The idea that there are vast areas of 'marginal land' ready to grow GM crops for food and agrofuels – which has been widely promoted since the first GM crops appeared in the 1990s – is increasingly recognized as spurious. 'Marginal' or 'waste' land seldom exists.

A recent review of this important issue (Econexus *et al*, 2008), found that such land is rarely idle. Rather it is more likely to be used by pastoralists, smallholders, Indigenous Peoples and women who utilize the land in a sustainable low impact way for hunting, and gathering food, fuel and building materials. These uses of land often have no visible impact and are often unrecognized. In addition, land may also be important for biodiversity including rare or important species, and for protecting water resources. Maintaining forests and other

ecosystems is also critical in mitigating climate change, since they store vast quantities of carbon and also play a vital part in the world's hydrological cycle.

The Food and Agriculture Organization (FAO) has also recognized the importance of so-called 'marginal land' to local people, and acknowledges that without rights or access to these lands they can be left destitute:

"For local farmers and pastoralists, however, access to this land may be their most valuable asset. When the land is expropriated, it can be difficult for local users, especially if they hold no formally recognized tenure rights, to negotiate sufficient compensation to ensure a sustainable livelihood." (FAO, Undated)

"While there is a perception that land is abundant in certain countries, these claims need to be treated with caution. In many cases land is already being used or claimed – yet existing land uses and claims go unrecognized because land users are marginalized from formal land rights and access to the law and institutions." (Cotula *et al*, 2009)

claim # 4: 'miracle' new gm crops will produce food during drought and stress

'miracle gm crops' are not currently available for commercial cultivation There is much made of 'miracle' GM crops, that would be capable of growing in 'marginal lands' or dealing with environmental extremes. Crops might, for example, be modified to cope with abiotic stresses such as salinity (Mollor *et al*, 2009) high levels of aluminum in soils (Magalhaes, 2007) or drought (EuropaBio, 2009). But these crops are nowhere near commercial cultivation at the moment. Claims made about such crops tend to be highly theoretical and speculative, as clearly illustrated in the discourse around drought-tolerant GM crops, for example.

*"If the right genes **could** be transferred to food crops, losses to drought **might** be significantly reduced and more organic matter **could** be returned to the soil. Interestingly, many proteins that confer tolerance to drought also confer tolerance to other stresses such as high and low temperature and salinity. The genes of the resurrection plant **could** offer multiple benefits."* (New Agriculturalist, undated) (emphasis added)

Genetic engineers have been trying to convert plants so that they make more efficient use of carbon dioxide and water. This means converting plants with Carbon 3 metabolism (C3) which include most plants e.g. trees, wheat and oilseed rape, to Carbon 4 metabolism (C4) plants. C4 plants include maize and sugar cane, which make more efficient use of carbon dioxide and water. Successful genetic modification conferring drought tolerance has so far proved impossible because this requires major changes to the metabolism of the plant. It is also worth

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pointing out that no seed will germinate and flourish in the absence of any moisture, which is so often the case in prolonged periods of drought in Africa, Australia and Europe.

Notably, Monsanto recently applied for an EU marketing consent for drought tolerant maize known as MON87460 and make the same point in their application:

“Under water-limited conditions, grain yield loss is reduced compared to conventional maize. However, like conventional maize, MON 87460 is still subject to yield loss under water-limited conditions, particularly during flowering and grainfill periods when maize yield potential is most sensitive to stress, by disrupting kernel development. Under severe water deficit, maize grain yield for MON87460, as well as conventional maize, can be reduced to zero.” (Monsanto application, undated)

What is important to note is that the information so far available from Monsanto does not include evidence that the GM maize will actually function under the limited water-stress circumstances outlined above (Monsanto application, undated).

In contrast, traditional breeding has produced varieties that mature quickly, increasing the chances of achieving a harvestable crop in some dry years. In other words, solutions already exist or are seriously viable, and it is these that need to be further researched in the interest of mitigating the impacts of climate change (Jane Ininda, 2006).

gm crops do not fare well under other stress conditions Many soils around the world have been rendered unusable by desertification and/or the overuse of irrigation, which produces toxic levels of salt in the top layers of the soil. So far no commercial crops have been developed, although genes occurring naturally in wheat have been identified in Australia, suggesting that marker-assisted breeding (traditional plant breeding assisted by identifying the desired gene in the parent plants first) may provide a more likely route to success.

Professor Tim Flowers of the School of Biological Sciences at the University of Sussex has stated:

“Evaluation of claims that biotechnology can produce salt-tolerant crops reveals that, after ten years of research using transgenic plants to alter salt tolerance, the value of this approach has yet to be established in the field. Biotechnologists have reasons for exaggerating their abilities to manipulate plants. If ‘biotechnology’ is to contribute tolerant crops, these crops may still be decades from commercial availability. The generation of drought tolerant crops is likely to have a similar period of development.” (FAO, 2010)

a focus on single varieties will reduce our ability to deal with climate change Some plant breeders recognize that the stresses crops will be subject to in the future will be highly variable and

unpredictable, because of climate change. Any one crop, for example, might be subject to drought or abnormally high rainfall or new pests and diseases. Growing monocultures based on single varieties will thus limit a crop’s ability to respond to changing conditions.

Instead, it has been proposed that mixed variety seed lots with a far broader genetic base should be sown. This would allow the crop to cope with different stresses in the way that natural ecosystems with their large gene pools can (Wolfe M, undated). Research from field-scale trials and laboratory studies confirm that biodiverse agriculture conserves the environment and delivers high and dependable yields. Monoculture yields may appear large when measured for a particular crop per hectare, yet on mixed farms the whole farm output per year is greater, less dependant on favorable weather conditions and more sustainable in the long term (Alteri M. A, 2005; FAO, 2004).

claim # 5: crops can be genetically modified to provide fuels

A member of the European biofuels industry commented that, *“In many ways, genetically modified (GM) crops and biofuels are made for each other. The enhanced yields available from the current generation of GM crops such as corn and soybeans can help farmers meet the growing feedstock demand for biofuels while still producing sufficient quantities of food and animal feed. In the future, GM crops with even higher yields and entirely novel GM varieties of grasses and trees should make biofuels production even more efficient and inexpensive* (Evans J, 2008).

In reality, however, the potential to increase yields from GM crops to supply demand for agrofuel feedstocks is far from proven. Improving the efficiency of some crops by genetically modifying them from C3 carbon metabolism to C4 carbon metabolism has not been achieved (as described above). This would require genetic changes that would fundamentally alter the metabolism of the plant and there is no certainty that the resulting plant will be able to thrive in the environment and produce high yields because successful crop plants are the sum of genetics, interaction between different genes, and interaction between genes and the environment. Introducing or changing a gene is thus no guarantee of success. Agrofuels production is also constrained by the limited efficiency of photosynthesis in converting solar energy into biomass (in practice only about 3-6% of total solar radiation is converted into biomass (FAO, 1997)); and by the availability of productive land that is not being used for other purposes.

GM soy and maize are being increasingly used for agrofules in North and South America. A recently published analysis of greenhouse gas emissions of bio-diesel production based on soya, which included land clearance, concluded:

“Our analysis provides a useful range of estimates. Our results indicate that soybean biodiesel production, despite its high savings from a pure engineering perspective dramatically increases greenhouse gas emissions compared to conventional diesel when factoring in emissions from land use change across a broad range of assumptions.” (Searchinger et al, undated)

The claims about the role of GM crops and trees in replacing fossil fuels is based on very limited evidence and poor analysis of the environmental and socioeconomic impacts that such a major shift in land use would have (see Claim 7 below for more on GM trees). Several detailed critiques have also been published exposing the threat of uncontrolled expansion of agrofuel production in general (Robertson GP, 2008; Searchinger TC et al, 2009) which could lead to:

- Loss of land previously used for food production
- Displacement of farmers and indigenous peoples
- Damage to biodiversity
- Increased agrochemical use (pesticides and fertilizers) and pollution from intensively managed plantations
- Poor working conditions
- Human rights abuses, and
- Substantial increases in GHG emissions.

claim # 6: gm crops could mean the end of reliance on nitrogen fertilizers

The ‘holy grail’ for genetic engineers is to be able to genetically modify nitrogen fixation into non-leguminous plants such as wheat and barley. There are already a large number of crop plants (eg peas, beans and clover) that have a symbiotic relationship with soil bacteria, which form nitrogen-fixing nodules on their roots. Sustainable farming systems already use these crops as part of rotation or sown under non-nitrogen fixing crops.

GM proponents claim that nitrogen-fixing crops could reduce the need for artificial nitrogen (N) fertilizers, thereby reducing the use of fossil fuels to manufacture, pack, transport and broadcast the fertilizers, as well as reducing the use of the fertilizers themselves. This could reduce emissions of both CO₂ and N₂O emissions.

However, despite these claims, there has been very little progress in terms of developing GM nitrogen-fixing crops. It may be that it simply proves to be too difficult to achieve this objective, because of the complexity of the nitrogen (N) fixation process, especially since it involves symbiotic relationships between two organisms: the genetic transformations required to achieve this are far more complex than the simple single

gene modifications associated with GM herbicide tolerance. Nitrogen fixing is also a highly energy intensive process which can impact negatively on yields. As one scientist observed: *“Nitrogen fixation in wheat was not considered a realistic prospect in the short term”* for this reason (APPG, 2008).

An FAO report in 2005 also explains why genetic modification for nitrogen fixation is so difficult:

“Nitrogen-fixation has long been a desired yet elusive ‘green’ biotechnology. However, the objective of improving-plant-Rhizobium symbiosis or other associations is not easy to achieve due to the complexities of the relationships, the multiplicity of factors involved, the specificity of the interaction between the two organisms, the influence of the environment on the system of expression and the possible competition between beneficial and other soil microflora.” (FAO, 2005)

In addition, high levels of nitrate can accumulate in the foliage of some leafy vegetables, eg lettuce and spinach, to the point where ‘Acceptable Daily Intakes’ could be exceeded (EFSA, 2008). Nitrate can be converted into nitrites and thence nitrosamines in the body, and these have been linked to cancer.

claim # 7: gm trees can sequester carbon

GM trees (often referred to as GE or genetically engineered trees) are already being developed for a range of uses, although China is the only country where they are currently being grown on a commercial scale. In China, Poplar (*Populus*) species have been genetically engineered, cloned and planted to prevent erosion. Elsewhere GM tree planting has been confined to a small number of test sites.

In the context of climate change, fast growing trees which fix more CO₂ than conventional trees would be superficially attractive as carbon sinks, and if the process was energy efficient, as sources of cellulose to produce ethanol for agrofuels. However the risks associated with GM trees are far more complex to assess than those associated with annual or biennial crops species. Trees differ in a number of important characteristics. A review of the scientific literature shows that due to the complexity of trees – which are organisms with large habitats and numerous interactions – it is not currently possible to undertake meaningful and adequate risk assessments of GM trees. Furthermore, trait-specific risk assessments are not appropriate.

In addition, both scientific literature and in-field experience show that contamination by and dispersal of GM trees will take place. Transgenic sterility is not a viable option because many species are capable of spreading by vegetative means and there is presently no transgenic sterility method that could be relied upon throughout the long life of a tree. Regulation of trees at

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the national level is also insufficient due to the large-scale dispersal of reproductive plant material by trees, much of which will be likely to cross national borders. All this makes GM trees a particularly compelling case for the application of the precautionary principle.

In China, GM trees are reproduced by taking cuttings (cloning) meaning the population has a very narrow genetic base. This approach makes GM trees especially vulnerable to serious disease and insect attacks, which would be difficult to control. In contrast, the regeneration of native forests through community-based tree planting has been demonstrated as a practical solution to stabilizing soils and preventing erosion, by The Green Belt Movement in Kenya (The Green Belt Movement, undated).

6.3 gm threatens real solutions to climate change

patenting natural climate genes Patents are used by large transnational corporations to protect markets and prevent farmers saving seeds from crops to sow the next year. The enforcement of such patents has been applied to control farming and ensure that biotechnology companies retain seed sales. The same companies (Monsanto, Bayer, Syngenta, BASF and Dupont) are systematically patenting any natural genes which could at some point be included in crops modified to mitigate and adapt to the changing conditions associated with climate change: drought, salinity, floods, high and low temperatures, and other abiotic stresses, as well as chemical loads in water and general stress. So far they have filed 532 patent documents covering 55 patent families (ETC, 2009).

The privatization of genetic resources in this way restricts farmers' and researchers' access to seeds and knowledge, and fuels the development of powerful monopolies (Tansey G. 2008). The top ten seed companies in the world already control 57% of seed sales (ETC, 2008). But restricting farmers' access to seeds, which they traditionally rely on from one year to the next by saving seed from each crop, is a threat to their food sovereignty (ETC, 2008).

In Africa there is also growing concern that the patenting of climate genes will undermine local initiatives for dealing with the huge challenge of climate change:

"Patent monopolies undermine and stymie climate adaptation by African farmers because it constrains the free exchange of and experimentation with crop germplasm – critical activities for the development of African solutions." (African Centre for Biosafety, 2009)

The importance that the industry places on securing intellectual property rights was also highlighted in a leaked strategy document produced by US lobby group, the Biotechnology Industries Organization (BIO), in the run up to the 2009 climate change negotiations in Copenhagen:

Food Sovereignty is the right of peoples, communities, and countries to control their own seeds, lands, water and food production through just and ecological systems; which ensures enough diverse, nutritious, locally produced and culturally appropriate food for all.

In the urban context this means the ability to produce or buy such food sourced locally and regionally from a network of diverse retail outlets and markets, which means building bridges between those who produce and consume food.

People's Food Sovereignty Forum, 2007

"Biotechnology provides key solutions to mitigating climate change. This is our opportunity to make those solutions more widely known, while protecting the ability of innovators to maintain intellectual property rights." (Bio, undated)

genuine solutions are threatened Genetically modifying crops to allow agriculture to adapt to and mitigate climate change is a high-risk strategy. Few of the supposed 'savior' crops have actually been demonstrated to work in the field, and their ability to meet much publicized expectations remains unknown. None have yet been commercialized. Davinder Sharma, an Indian commentator on agriculture and GM crops, succinctly sums up why such claims are being made:

"These assertions are not amusing, and can no longer be taken lightly. I am not only shocked but also disgusted at the way corporations try to fabricate and distort the scientific facts, and dress them up in such a manner that the so-called 'educated' of today will accept them without asking any questions." (Sharma D, 2009)

This focus on GM technology diverts attention away from another successful approach to agriculture that already has a proven track record when it comes to addressing some of the challenges linked to climate change: agro-ecology. This system of food production is championed by Via Campesina, the global network of peasant farmers, who observe that:

"Agro-ecology and other sustainable food production systems are preserving biodiversity and increasing food productivity. These systems have in practice shown alternatives to the high-tech, expensive and unsustainable model of the 'green revolution.'" (IAASTD, 2008)

In April 2008, the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) published its report based on four years of deliberation looking into the scientific, social science and economic aspects of the genetic modification of crops. The report included 20 key findings, amongst which was a call for far greater emphasis on

agro-ecological approaches to land management and the need to develop agricultural knowledge, science and technology (AKST) to this end (GM Freeze, 2008).

“An increase and strengthening of AKST towards agroecological sciences will contribute to addressing environmental issues while maintaining and increasing productivity. Formal, traditional and community-based AKST need to respond to increasing pressures on natural resources, such as reduced availability and worsening quality of water, degraded soils and landscapes, loss of biodiversity and agroecosystem function, degradation and loss of forest cover and degraded marine and inshore fisheries.” (IAASTD, 2008)

The overriding message of the report was summed up thus:

“Agriculture has a footprint on all of the big environmental issues, so as the world considers climate change, biodiversity, land degradation, water quality, etc. they must also consider agriculture which lies at the centre of these issues and poses some uncomfortable challenges that need to be faced. We’ve got to make sure the footprint of agriculture on climate change is lessened; we have to make sure that we don’t degrade our soil, we don’t degrade the water, and we don’t have adverse effects on biodiversity. There are some major challenges, but we believe that by combining local and traditional knowledge with formal knowledge these challenges can be met.” (Professor Robert Watson, Director IAASTD and Chief Scientist DEFRA UK) (IAASTD press release, 2008)

The IAASTD did not endorse GM crops as the solution, much to the annoyance of the biotechnology industry and the USA, Australia and Canada, all of whom provided amended text to the final report to record their disquiet (IAASTD draft report, 2008). However, 58 countries have endorsed the IAASTD findings without such reservations.

In October 2008, the UNEP-UNCTAD Capacity-building Task Force on Trade, Environment and Development also published a report on *“Organic Agriculture and Food Security in Africa,”* which supported the IAASTD’s finding that agro-ecological approaches to land management provide the best options for dealing with the many tasks being asked of farmers. It concluded that:

“Organic agriculture can increase agricultural productivity and can raise incomes with low-cost, locally available and appropriate technologies, without causing environmental damage. Furthermore, evidence shows that organic agriculture can build up natural resources, strengthen communities and improve human capacity, thus improving food security by addressing many different causal factors simultaneously.” (UNEP, 2008)

However, many agro-ecological solutions to the major problems of drought and saline soils (which often result from the use of ecologically inappropriate crops and the overuse of irrigation on

hybrid crops) remain unavailable to many farmers. A failure to make money available to fund extension services and infrastructure is a serious impediment. In some countries land tenure for farmers, and especially women, also makes the adoption of agro-ecological practices more difficult.

6.4 agro-ecological systems can tackle climate change

Agro-ecological systems have been identified as key to facing the challenge of feeding a growing population in a warming world. They respect the multi-functionality of agriculture, which is especially important for resource poor farmers in the developing world. Agro-ecological practices can reduce greenhouse gas emissions from agriculture in a variety of ways:

a) increasing soil organic matter

- Practicing crop rotations.
- Including grass/legume crops to improve soil structure.
- Adopting mixed cropping, crop rotation and crops breaks.
- Avoiding excessive cultivation to reduce carbon losses.
- Avoiding the excessive use of fertilizers, which reduces natural nutrient cycles and emits greenhouse gases.
- Recycling organic matter (such as animal manure and crop waste) back into the soil to increase soil fertility and water holding capacity, and to improve the soil structure for better root growth and to prevent soil erosion.
- Avoiding the excessive use of irrigation, which can cause salt to build up in top-soil to toxic levels.



six the new promise: gm crops and climate change

continued

b) agro-forestry

Agro-forestry is “a collective name for land-use systems and practices where woody perennials are deliberately integrated with crops and/or animals on the same land management unit.” (FAO 1993) Agro-forestry systems set out to create diverse cropping systems with many layers of productive crops from the ground to the upper canopy of the trees. In many areas of the world where farmers have to deal with intermittent and unreliable circumstances, agro-forestry can provide a more sustainable form of land management than large-scale crop monocultures.

c) water harvesting

There are several techniques for harvesting seasonal rainfall (Practical Action, undated) to make it available for crops during dry seasons, including the diversion of water using check dams; small-scale reservoirs; and contour plowing to capture run-off more effectively.

d) drip irrigation

Drip or trickle irrigation systems are a water-efficient alternative to spray irrigation: water is delivered to plants in the correct amounts close to their roots.

e) increasing soil organic matter

- Use of water efficient irrigation so that water is applied at rates crops can cope with.
- Regulation of ground water abstraction to prevent over pumping and the intrusion of saline waters from the sea.
- Building dykes and levees to prevent sea water inundating farm land in tropical storms (this also helps to protect communities living near coastlines).
- Leaching (flushing) of soils using ‘clean’ water to wash salt out of the root zone.
- Leaching using natural rainfall often using a salt tolerant crop such as millet (Primefacts, 2006) to produce food whilst this takes place.
- Planting deep-rooted trees and shrubs to lower water tables beneath crops.
- Improved drainage of irrigated land.
- Improved infiltration of irrigation water using cultivation techniques, such as contour plowing (for example furrowing the soil to increase the rate at which water enters the soil).
- Incorporation of organic matter to improve infiltration.
- Use of mulches to reduce evaporation losses.

- Incorporation of crop residues into the soil which would be lost if these were diverted into secondary biofuel production.
- Using conventional breeding (with marker-assisted selection) to develop saline tolerant varieties based on local gene pools.
- Support research in to seed priming – a technique that allows crops to grow under saline conditions (Iqbal M *et al*, 2006).

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