GM SOY
Sustainable? Responsible?

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Summary of key findings

Awareness is growing that many modern agricultural practices are unsustainable and that alternative ways of ensuring food security must be found.

In recent years, various bodies have entered the sustainability debate by attempting to define the production of genetically modified Roundup Ready® (GM RR) soy as sustainable and responsible. These include:

- ISAAA, a GM industry-supported group[1]
- Plant Research International at Wageningen University, the Netherlands, which has issued a paper presenting the arguments for the sustainability of GM RR soy[2]
- The Round Table on Responsible Soy (RTRS),[3] a multi-stakeholder forum with a membership including NGOs such as WWF and Solidaridad and multinational companies such as ADM, Bunge, Cargill, Monsanto, Syngenta, Shell, and BP

This report assesses the scientific and other documented[4] evidence on GM RR soy and asks whether this definition is justified.

More than 95 per cent of GM soy (and 75 per cent of other GM crops) is engineered to tolerate glyphosate herbicide, the most common formulation of which is Roundup. The RR gene allows the growing crop to be sprayed with glyphosate, killing weeds but allowing the crop to survive. Monsanto is the leading manufacturer of glyphosate herbicide as well as the leading producer of GM seed.

GM RR soy was first commercialized in the United States in 1996. Today, GM RR varieties make up over 90 per cent of soy plantings in North America and Argentina and are widely used in Brazil, Paraguay, Uruguay and Bolivia.

In 2009, 14 million farmers planted 134 million hectares (330 million acres) of GM crops.[4] However, that means 99 per cent of all farmers did not grow GM crops and more than 90 per cent of all arable land was GM-free. GM RR soy is the world's most widely planted GM crop, with 69 million hectares in 2009.[5]

This is a summary of findings from the full report, GM Soy: Sustainable? Responsible?

HEALTH EFFECTS OF GLYPHOSATE

The rapid expansion of GM RR soy has led to large increases in the use of glyphosate. It is often claimed that glyphosate is safe for people and the environment. But scientific research challenges these claims.

Studies show that glyphosate has serious toxic effects on health and the environment. The added ingredients or adjuvants in Roundup increase its toxicity.

Harmful effects from glyphosate and Roundup have been found even at levels that are commonly used in agriculture and found in the environment.

Findings include:

In human cells, Roundup causes total cell death within 24 hours. These effects are found at levels far below those recommended for agricultural use and corresponding to low levels of residues found in food or feed.[6]

- Glyphosate herbicides are endocrine disruptors (substances that interfere with hormone functioning) in human cells. These effects are found at levels up to 800 times lower than residue levels allowed in some GM crops used for animal feed in the United States. Glyphosate herbicides damage DNA in human cells at these levels.[7]
- Glyphosate and Roundup adjuvants damage human placental cells in concentrations lower than those found with agricultural use.[8 9 10]
- Glyphosate and Roundup damage human embryonic cells and placental cells, in concentrations well below those recommended for agricultural use.[11]
- Roundup is toxic and lethal to amphibians. Applied at the rate recommended by the manufacturer for agricultural use, Roundup caused a 70 per cent decline in the species richness of tadpoles.[12] An experiment using lower concentrations still caused 40 per cent mortality.[13]
- Glyphosate herbicides and glyphosate's main metabolite (environmental breakdown product), AMPA, alter cell cycle checkpoints in sea urchin embryos by interfering with the physiological DNA repair machinery.[14 15 16 17] Such disruption is known to lead to genomic instability and the possible development of human cancers.
- Glyphosate is toxic to female rats and causes skeletal malformations in their foetuses.[18]
- AMPA, the major environmental breakdown product of glyphosate, causes DNA damage in cells.[19]

These findings show that glyphosate and Roundup are highly toxic to many organisms and to human cells.

New study confirms glyphosate's link with birth defects

In 2009 Argentine government scientist Professor Andrés Carrasco[20] announced his findings that glyphosate herbicide causes malformations in frog and chicken embryos, in doses much lower than those used in agricultural spraying. The malformations were of a similar type to those seen in the offspring of humans exposed to such herbicides.[21]

Carrasco commented, "The findings in the lab are compatible with malformations observed in humans exposed to glyphosate during pregnancy." He added that his findings have serious implications for people because the experimental animals share similar developmental mechanisms with humans.[22]

Carrasco said that most of the safety data on glyphosate herbicides and GM soy were provided by industry and are not independent.

In their study, Carrasco's team criticized Argentina's over-reliance on glyphosate caused by the expansion of GM RR soy, which in 2009 covered 19 million hectares – over half the cultivated area of the country. They noted that 200 million litres of glyphosate herbicide are used in the country to produce 50 million tons of soybeans per year.[23 24]

Carrasco said in an interview that people living in soy-producing areas of Argentina began reporting problems in 2002, two years after the first big harvests of GM RR soy. He said, "I suspect the toxicity classification of glyphosate is too low ... in some cases this can be a powerful poison."[25]

Carrasco found malformations in frog and chicken embryos injected with 2.03 mg/kg glyphosate. The maximum residue limit allowed in soy in the EU is 20 mg/kg, 10 times higher.[26]

Argentina: Proposed ban on glyphosate and and court ruling

After the release of Carrasco's findings, environmental lawyers petitioned the Supreme Court of Argentina to ban glyphosate. But Guillermo Cal, executive director of CASAFE (Argentina's crop protection trade association), said a ban would mean "we couldn't do agriculture in Argentina".[27]

No national ban was implemented. But in March 2010, a court in Santa Fe province, Argentina upheld a decision blocking farmers from spraying agrochemicals near populated areas.[28]

Argentina: Chaco provincial government report

In April 2010 a commission opened by the provincial government of Chaco in Argentina completed a report analyzing health statistics in the town of La Leonesa and other areas where soy and rice crops are heavily sprayed.[29] The commission reported that the childhood cancer rate tripled in La Leonesa from 2000 to 2009. The rate of birth defects increased nearly fourfold over the entire state of Chaco.

This dramatic increase of disease coincided with the expansion of glyphosate and other agrochemical spraying in the province.

A member of the commission that prepared the study, who asked not to be identified due to the "tremendous pressures" they were under, said, "We don't know how this will end, as there are many interests involved."[30]

Argentina: Sprayed community prevented from hearing glyphosate researcher

There is intense pressure on researchers and residents in Argentina not to speak out about the dangers of glyphosate and other agrochemicals. In August 2010 Amnesty International reported[31] an incident in La Leonesa, a town where residents have actively opposed agrochemical spraying. An organized mob violently attacked people who gathered to hear a talk by Professor Andrés Carrasco on his research findings that glyphosate caused malformations in frogs. Three people were seriously injured and the event had to be abandoned. Carrasco and a colleague shut themselves in a car and were surrounded by people making violent threats and beating the car for two hours. Witnesses said they believed the attack was organized by local officials and a rice producer, in order to protect agro-industry interests.

Epidemiological studies on glyphosate

Epidemiological studies on glyphosate exposure show an association with serious health problems, including:

- premature births and miscarriages[32]
- multiple myeloma (a type of cancer)[33]
- non-Hodgkin's lymphoma (another type of cancer)[34 35]
- DNA damage.[36]

By themselves, these epidemiological findings cannot prove that glyphosate is the causative factor. But the toxicological studies on glyphosate cited above confirm that it poses health risks.

Indirect toxic effects of glyphosate

Glyphosate is marketed as a product that breaks down rapidly and harmlessly in the environment. But this is not true.

In soil, glyphosate has a half-life (the length of time it takes to lose half its biological activity) of between 3 and 215 days.[37 38] In water, glyphosate's half-life is 35–63 days.[39]

Glyphosate reduces bird populations[40] and is toxic to earthworms.[41 42]

Claims of the environmental safety of Roundup have been overturned in court in New York[43] and France.[44]

HEALTH RISKS OF GM FOODS AND CROPS

The most obvious risks of GM RR soy relate to the glyphosate herbicide used with the crop. But another set of risks must also be considered: those arising from genetic manipulation.

Do regulators ensure the safety of GM crops and foods?

The US Food and Drug Administration (FDA) allowed the first GM foods onto world markets in the early 1990s.

Contrary to claims by the GM industry and its supporters, the FDA has never approved any GM food as safe. Instead, it has de-regulated GM foods, ruling that they are "substantially equivalent" to their non-GM counterparts and do not require any special safety testing. The term "substantial equivalence" has never been scientifically or legally defined.

The FDA's ruling was widely recognized as an expedient political decision with no basis in science. Controversially, the FDA ignored the warnings of its own scientists that GM is different from traditional breeding and poses unique risks.[45]

In the US, safety assessment of GM foods is a voluntary process, driven by the commercializing company. The company chooses which data to submit to the FDA and the FDA sends the company a letter reminding the company that the responsibility for ensuring the safety of the GM food in question rests with the company.[46]

The European GM regulator, EFSA (European Food Safety Authority), like the FDA, believes that feeding trials with GM foods are generally unnecessary and bases its safety assessment of GM foods on the assumption that GM foods are substantially equivalent to their non-GM equivalents. When differences have been found, EFSA often dismisses them as not being of "biological significance".[47]

Is GM just an extension of natural breeding?

GM is not just an extension of conventional plant breeding. It uses laboratory techniques to insert artificial gene units into the host plant's genome – a process that would never happen in nature. The process is imprecise and can cause widespread mutations[48] that can disrupt the functioning of hundreds of genes, leading to unpredictable and potentially harmful effects.[49]

Unexpected ill effects have been found in experimental animals fed on GM crops and foods that have been commercialized. These include GM maize[50 51 52 53] and canola/oilseed rape[54] as well as soy (see below, "Hidden GM RR soy in animal feed").

GM foods and crops: Restrictive research climate

The body of safety data on GM crops and foods is not as comprehensive as it should be, given the length of time they have been in the food and feed chain. This is because GM companies use their patent-based control of the crops to restrict research. They often bar access to seeds for testing, or retain the right to withhold permission for a study to be published.[55]

There is also a well-documented pattern of GM industry attempts to discredit scientists whose research reveals problems with GM crops.[56] UC Berkeley researchers David Quist and Ignacio Chapela found themselves the targets of an orchestrated campaign to discredit them after they published research showing GM contamination of Mexican maize varieties.[57] An investigation traced the campaign back to the Bivings Group, a public relations firm contracted by Monsanto.[58 59]

Is GM RR soy safe to eat?

Since GM RR soy was approved for commercialization, studies have found ill effects in laboratory animals fed on GM RR soy, which were not seen in non-GM-fed control groups:

- Mice fed GM RR soy had cellular changes in the liver, pancreas and testes.[60 61 62]
- Mice fed GM soy showed more acute signs of ageing in their liver.[63]
- Rabbits fed GM soy showed enzyme function disturbances in kidney and heart.[64]
- Female rats fed GM soy showed changes in their uterus and ovaries.[65]
- In a multigenerational study on hamsters, most of the GM soy-fed hamsters had lost the ability to reproduce by the third generation. They also had slower growth and higher mortality among pups.[66]

The findings suggest that GM RR soy could pose serious health risks to humans. The fact that differences were found between GM-fed and non-GM-fed animals contradicts the FDA's assumption that GM soy is substantially equivalent to non-GM soy.

Hidden GM RR soy in animal feed

Around 38 million tons of soymeal per year are imported into Europe, which mostly goes into animal feed. About 50–65 percent of this is GM or GM-contaminated, with 14 to 19 million tons GM-free. Products from animals raised on GM feed do not have to carry a GM label, based on assumptions including:

- GM DNA does not survive the animal's digestive process
- GM-fed animals are no different from animals raised on non-GM feed
- meat, fish, eggs and milk from animals raised on GM feed are no different from products from animals raised on non-GM feed.

However, these assumptions are false. Studies show that differences can be found in animals raised on GM RR soy animal feed, compared with animals raised on non-GM feed, and that GM DNA can be detected in the milk and body tissues (meat) of such animals.

- DNA from plants is not completely degraded in the gut but is found in organs, blood, and even the offspring of mice.[67] GM DNA is no exception.
- GM DNA from GM maize and GM soy was found in milk from animals raised on these GM crops. The GM DNA was not destroyed by pasteurization.[68]
- GM DNA from soy was found in the blood, organs, and milk of goats. An enzyme, lactic dehydrogenase, was found at significantly raised levels in the heart, muscle, and kidneys of kids fed GM RR soy.[69] This enzyme leaks from damaged cells and can indicate cellular injury.

GM RR SOY AND FARMERS

Many of the promised benefits to farmers of GM crops, including GM RR soy, have not materialized. On the other hand, unexpected problems have arisen.

Does GM RR soy give higher yields?

The claim that GM crops give higher yields is often uncritically repeated in the media. But it is not accurate.

At best, GM crops have performed no better than their non-GM counterparts, with GM soy giving consistently lower yields. A review of over 8,200 university-based soybean varietal trials in the US found a yield drag of between 6 and 10 per cent for GM RR soy compared with non-GM soy.[70] Field trials of GM and non-GM soy suggested that half the drop in yield was due to the disruptive effect of the GM transformation process.[71] However, the glyphosate herbicide used with GM RR soy is also known to reduce crop vigour and yield (see "Glyphosate has negative impacts on soil and crops").

Data from Argentina show that here, too, GM RR soybean yields are the same as, or lower than, non-GM soybean yields.[72]

Claims of higher yields from Monsanto's new generation of RR soybeans, RR 2 Yield, have not been borne out. A study of US farmers who planted RR 2 soybeans in 2009 concluded that the new variety "didn't meet their [yield] expectations".[73] In June 2010 the state of West Virginia launched an investigation of Monsanto for false advertising claims that RR 2 soybeans gave higher yields.[74]

GM RR soy encourages superweed explosion

Glyphosate-resistant weeds (superweeds) are the major problem for farmers who grow GM RR soy. Soy monocultures that focus on a single herbicide, glyphosate, set up the conditions for increased herbicide use. As weeds gain resistance to glyphosate over time, more of the herbicide is required to control weeds. A point is reached when no amount of glyphosate is effective and farmers are forced onto a treadmill of using older, toxic herbicides such as 2,4-D.[75 76 77 78 79 80 81 82 83]

Many studies confirm that the widespread use of glyphosate on RR soy has led to an explosion of glyphosate-resistant weeds in North and South America, as well as other countries.[84 85 86 87 88 89]

It is widely recognized that glyphosate-resistant weeds are rapidly undermining the viability of the entire Roundup Ready farming model. A St. Louis Post-Dispatch article said, "this silver bullet of American agriculture is beginning to miss its mark."[90]

An article in the New York Times confirmed that throughout the United States, farmers "are being forced to spray fields with more toxic herbicides, pull weeds by hand and return to more labour-intensive methods like regular ploughing". Eddie Anderson, a farmer who has used no-till farming for 15 years but is planning to return to ploughing, said, "We're back to where we were 20 years ago."

Does GM RR soy reduce pesticide/ herbicide use?

Minimizing the use of agrochemicals is a key tenet of sustainability. The GM industry has long claimed that GM crops have decreased pesticide use ("pesticide" is used here in its technical sense to include herbicides, insecticides, and fungicides. Herbicides are, in fact, pesticides).

North America: The US is the world's leading producer of GM crops, with 64 million hectares grown in 2009,[91] 28.6 million hectares of which are RR soy.[92]

The agronomist Dr Charles Benbrook examined the claim that GM crops reduce pesticide use in a 2009 report using data from the US Department of Agriculture (USDA) and the USDA's National Agricultural Statistics Service (NASS).[93] Benbrook found that compared with pesticide use in the absence of GM herbicide-tolerant and Bt crops, farmers applied 318 million more pounds of pesticides as a result of planting GM seeds over the first 13 years of commercial use. In 2008, GM crop fields required over 26 per cent more pounds of pesticides per acre (1 acre = approximately 0.4 hectares) than fields planted to non-GM varieties.

GM herbicide-tolerant crops increased herbicide use by a total of 382.6 million pounds over 13 years – swamping the modest 64.2 million pound reduction in chemical insecticide use attributed to Bt maize and cotton.

Based on NASS data, Benbrook calculates an increase in herbicide use of 41.5 million pounds in 2005 due to the planting of GM RR soy, as compared with non-GM soy. 2005 is singled out because the last NASS survey of soybean herbicide use was in 2006. Over the full 13 years, GM RR soybeans increased herbicide use by 351 million pounds (about 0.55 pounds per acre), compared with the amount that would have been applied in the absence of herbicide-tolerant crops. GM RR soy accounted for 92 per cent of the total increase in herbicide use across the US's main three herbicide-tolerant crops: soy, maize, and cotton.[94]

South America: In Argentina, according to Monsanto, GM RR soy makes up 98 per cent of the soybean plantings.[95] GM RR soy has driven dramatic increases in agrochemical use in the country.[96 97]

Dr Charles Benbrook analyzed changes in herbicide use in Argentina triggered by the expansion of GM RR soy with no-till (a farming method that avoids ploughing with the aim of conserving soil) between 1996 and 2004, based on data from CASAFE (Argentina's crop protection trade association).[98] Benbrook found that the expansion of RR soy has run in parallel with steadily increasing rates of glyphosate applications on soy per hectare. Each year, farmers had to apply more glyphosate per hectare than the previous year to achieve weed control. The average rate of glyphosate application on soy increased steadily each year from 1.14 kg/hectare in 1996/97 to 1.30 kg/hectare in 2003/04.

Also, farmers have had to spray more frequently. The average number of glyphosate applications on soy increased from 1.8 in 1996/97 to 2.5 in 2003/04.[99] This was due to the rise in glyphosate-resistant weeds, as farmers have had to use more and more glyphosate to try to control weeds. This is a fundamentally unsustainable approach to soy production.

It is often claimed that rising glyphosate use is positive because it is less toxic than the other chemicals it replaces.[100] But the research findings above ("Health effects of glyphosate") show that glyphosate is highly toxic.

In addition, in Argentina, since 2001, the volumes applied of other herbicides, including the toxic 2,4-D and Dicamba, have gone up, not down. This is due to farmers resorting to non-glyphosate herbicides to try to control glyphosate-resistant weeds.[101]

GM RR soy in Argentina: Ecological and agronomic problems

The GM RR soy farming model – no-till and heavy herbicide use – has caused serious ecological and agronomic problems in Argentina, including:

- The spread of glyphosate-resistant weeds
- Erosion of soils
- Loss of soil fertility and nutrients
- Dependence on synthetic fertilizers
- Deforestation
- Potential desertification
- Loss of species and biodiversity.

The RR soy model has spread not only into the Pampas but also into areas previously rich in biodiversity, such as the Yungas, Great Chaco, and the Mesopotamian Forest.[102]

GM RR soy production depletes soils in South America

The expansion of soy monoculture in South America since the 1990s has resulted in an intensification of agriculture on a massive scale. This has resulted in a decline in soil fertility and an increase in soil erosion, rendering some soils unusable.[103] A study of the nutrients of Argentinean soils predicts that they will be totally consumed in 50 years at the current rate of nutrient depletion and increase in soybean area.[104] Farmers have abandoned their traditional soil-conserving practice of crop rotation to accommodate the rapid expansion of the soy market.[105]

In areas of poor soils, within two years of cultivation, synthetic nitrogen and mineral fertilizers have to be applied heavily.[106] This is an unsustainable approach to soil management from an economic as well as an ecological point of view.

Glyphosate has negative impacts on soil and crops

Many studies show that glyphosate has negative effects on soil and crops.

Glyphosate reduces nutrient uptake in plants. It binds trace elements, such as iron and manganese, in the soil and prevents their transportation from the roots up into the shoots.[107] The result is reduced plant growth. GM RR soy plants treated with glyphosate have lower levels of manganese and other nutrients and reduced shoot and root growth.[108]

Lower nutrient levels in plants have implications for humans, as food derived from these crops have reduced nutritional value.

Glyphosate causes problems in root development and nitrogen fixation, reducing the growth of soy plants. Glyphosate further reduces yield in drought conditions.[109]

There is a well-documented link between glyphosate and increased plant diseases. Don Huber, plant pathologist and professor emeritus at *Purdue University,* said, "There are more than 40 diseases reported with use of glyphosate, and that number keeps growing as people recognize the association [between glyphosate and disease]."[110 111 112] This may be in part because the reduced nutrient uptake caused by glyphosate makes plants more susceptible to disease.

Many studies show a link between glyphosate applications and Fusarium, a fungus that causes wilt disease and sudden death syndrome in soy and other crops.[113 114 115 116 117 118] Fusarium produces toxins that can enter the food chain and harm humans and livestock.

Huber said, "Glyphosate is the single most important agronomic factor predisposing some plants to both disease and toxins [produced by Fusarium]. These toxins can produce a serious impact on the health of animals and humans. Toxins produced can infect the roots and head of the plant and be transferred to the rest of the plant. The toxin levels in straw can be high enough to make cattle and pigs infertile."[119]

A review of research on glyphosate's effects on plant diseases concluded, "Ignoring potential non-target detrimental side effects of any chemical, especially used as heavily as glyphosate, may have dire consequences for agriculture such as rendering soils infertile, crops non-productive, and plants less nutritious," undermining agricultural sustainability and human and animal health.[120]

PROBLEMS EMERGING WITH NO-TILL

It is often argued that GM RR soy is environmentally sustainable because it enables the use of no-till, a farming method that avoids ploughing with the aim of conserving soil. In the GM RR soy/no-till model, seed is planted directly into the soil and weeds are controlled with glyphosate herbicide rather than mechanical methods.

Advantages claimed for no-till are that it decreases water evaporation and runoff, soil erosion and topsoil depletion. Disadvantages include soil compaction and increased soil acidity.

Pests and diseases: Studies have found that no-till encourages plant pests and diseases, which thrive in the crop residue left on the soil.[121] The link between no-till and increased pest and disease problems has been well documented in studies in South America and elsewhere.[122] [123] [124] [125] [126] [127] [128]

Environmental impact: Once the energy and fossil fuel used in herbicide production are taken into account, claims of environmental sustainability for GM RR soy with no-till systems collapse.

One report analyzed the environmental footprint or Environmental Impact Quotient (EIQ) of GM and non-GM soy in Argentina and Brazil. EIQ is calculated on the basis of the impact of herbicides and pesticides on farm workers, consumers, and ecology.

The report found that in Argentina, the EIQ of GM RR soy is higher than that of conventional soy in both no-till and tillage systems because of the herbicides applied.[129] Also, the adoption of no-till raises the EIQ, whether the soy is GM RR or non-GM.

The authors conclude that the increased EIQ of RR soy is due to the spread of glyphosate-resistant weeds, which force farmers to apply more glyphosate.[130]

Carbon sequestration: GM proponents claim that no-till agriculture linked to the cultivation of GM soy benefits the environment because it enables soils to store more carbon, removing it from the atmosphere and offsetting global warming. But a review of the scientific literature (over 50 studies) found that no-till fields sequestered no more carbon than ploughed fields when carbon changes at soil depths greater than 30 cm are examined.[131]

Energy use: It is often claimed that no-till with GM RR soy farming model saves energy because it reduces the number of times the producer must pass across the field with the tractor. But data from Argentina show that, while no-till reduces farm operations (tractor passes), these energy savings are wiped out when the energy used in the production of herbicides and pesticides applied to GM RR soy is taken into account. When these factors are considered, the production of RR soy requires more energy than the production of conventional soy.[132]

While there are ecological and agronomic benefits to no-till when it is part of a wider approach to sustainable farming, the no-till with glyphosate model that accompanies GM RR soy is unsustainable.

SOCIOECONOMIC IMPACTS OF GM RR SOY

Argentina: The soy economy

Argentina is frequently cited[133] as an example of the economic success of the GM RR soy model. There is no doubt that the rapid expansion of GM RR soy in Argentina since 1996 has brought economic growth to a country in a deep recession. However, it is a fragile and limited type of success, almost entirely dependent on exports.[134]

More seriously, critics of the soy economy say it has had severe social and economic impacts on ordinary people. They say it has decreased domestic food security and food buying power among a significant sector of the population, as well as promoting inequality in wealth distribution.[135] [136] These trends have led to predictions that the economic model is an unsustainable one of “boom and bust”.[137]

- Pengue (2005)[138] linked RR soy production to social problems in Argentina, including:
- Displacement of farming populations to the cities of Argentina
- Concentration of agricultural production into the hands of a small number of large-scale agribusiness operators
- Reductions in food production and loss of access by many people to a varied and nutritious diet.

Pengue noted that the introduction of RR soy into Argentina had damaged food security by displacing food crops. Soy production had, in the previous five years, displaced 4,600,000 hectares of land previously dedicated to other production systems such as dairy, fruit trees, horticulture, cattle, and grain.[139]

Certainly, the soy economy has not succeeded in feeding the Argentine people. Government statistics show that between 1996 (the year when GM soy was first grown) and 2002 the number of people lacking access to a “Basic Nutrition Basket” (the government’s measure of poverty) grew from 3.7 million to 8.7 million, or 25 per cent of the population. By the second half of 2003, over 47 per cent of the population was below the poverty line and lacked access to adequate food.[140]

GM RR soy production is a form of “farming without farmers” and has caused unemployment problems. In RR soy monocultures, labor levels decrease by between 28 per cent and 37 per cent, compared to conventional farming methods.[141] In Argentina, high-tech RR soy production needs only two workers per 1000 hectares per year.[142]

Economic impacts of GM RR soy on US farmers

A study using US national survey data found no significant increase in on-farm profits from the adoption of GM RR soy in the US.[143]

A study on US farmers growing GM RR soy found that in most cases the cost of the technology was higher than the cost savings. Therefore the adoption of GM RR soy had a negative economic impact, compared to the use of conventional seeds.[144]

A 2006 report for the European Commission on GM crop adoption worldwide concludes that economic benefits of GM crops for farmers are “variable”. It says that adoption of GM RR soy in the US has “had no significant effect on on-farm income”.

In light of this finding, the report asks, “Why are US farmers cultivating HT [herbicide-tolerant, GM RR] soybean and increasing the HT soybean area?” The authors conclude that the high take-up of the crop is due to “crop management simplification.”[145] This is a reference to simplified weed control using glyphosate herbicides. But four years on from the report’s publication, the explosion of glyphosate-resistant weeds has made even the claim of simplified weed control difficult to justify.

RR seed price rises in the US

A 2009 report[146] showed that GM seed prices in the US have increased dramatically compared to non-GM and organic seeds, cutting average farm incomes for US farmers growing GM crops. In 2006, GM soybean seed cost 4.5 times as much as the price of GM soybeans. Non-GM soybean seeds only cost 3.2 times as much as non-GM soybeans.

In the 25 years from 1975 through 2000, soybean seed prices rose a modest 63 per cent. Over the next ten years, as GM soybeans came to dominate the market, the price rose an additional 230 per cent. The $70 per bag price set for RR 2 soybeans in 2010 was twice the cost of conventional seed and reflected a 143 per cent increase in the price of GM seed since 2001.

It is reasonable to ask why farmers pay such high prices for seed. Recent events suggest that they have little choice. The steep price increases for RR 2 soybeans and “SmartStax” maize seeds in 2010 triggered an antitrust investigation by the US Department of Justice into the consolidation of big agribusiness firms that has led to anti-competitive pricing and monopolistic practices. Farmers have been giving evidence against firms like Monsanto.[147 148]

Farmers moving away from GM RR soy

In recent years, reports have emerged from North and South America suggesting that farmers are moving away from GM soy.

A report from the Ohio State University extension service in 2009 said that the growing interest in non-GM soybeans stemmed from ‘cheaper seed and lucrative premiums”. In anticipation of this growth in demand, seed companies were doubling or tripling their non-GM soybean seed supply for 2010.[149]

Similar reports emerged from Missouri and Arkansas.[150 151] Agronomists pointed to three factors driving this renewed interest in conventional soybean seed:

- The high and rising price of RR seed
- The spread of glyphosate-resistant weeds

Farmers’ desire to regain the freedom to save and replant seed, a traditional practice prohibited with Monsanto’s patented RR soybeans.

In Brazil’s top soy state of Mato Grosso, farmers are also reported to be favouring conventional seeds due to poor yields from GM seeds.[152]

Farmers’ access to non-GM seed restricted

As farmers attempt to regain power of choice over seed, Monsanto is trying to take it away by restricting access to non-GM varieties. In Brazil, the Brazilian Association of Soy Producers of Mato Grosso (APROSOJA) and the Brazilian Association of Non Genetically Modified Grain Producers (ABRANGE) have complained that Monsanto is restricting the access of farmers to conventional (non-GM) soybean seeds by imposing sales quotas on seed dealers, requiring them to sell 85 per cent GM soy seed and no more than 15 per cent non-GM.[153]

GM contamination and market losses

Consumers in many areas of the world reject GM foods. As a result, several instances of GM contamination have severely impacted the industry and markets.

Contamination with unapproved GMOs threaten the entire food sector. Examples include:

In 2006 Bayer’s GM LL601 rice, which was grown for only one year in field trials, contaminated the US rice supply and seed stocks.[154] Bayer has since been mired in litigation brought by affected US rice farmers and has had to pay millions of dollars in compensation.[155]

In 2000 the US maize supply was contaminated with GM StarLink maize. The discovery led to massive recalls of StarLink-contaminated food products worldwide. The incident lost US producers between $26 and $288 million in revenue.[156]

Contamination with approved GMOs, including GM RR soy, threatens the growing GMO-free sectors of the market. For instance, under the German “Ohne Gentechnik” and the Austrian “Gentechnik-frei erzeugt” programmes, and also for retailers such as Marks & Spencer in the UK, animal products are sold as produced with non-GM feed.

Producers and others in the supply chain recognize that discovery of GM contamination could compromise consumer confidence and goodwill, resulting in damaging economic impacts.

HUMAN RIGHTS VIOLATED

Paraguay: Violent displacement of people

Paraguay is one of the world’s leading suppliers of GM RR soy, with a projected 2.66 million hectares of the crop in 2008, up from 2.6 million hectares in 2007. Around 95 per cent of the total soybean plantings are GM RR soy.[157]

The expansion of soy in the country has been linked to serious human rights violations, including incidents of land grabbing.

A documentary for Channel 4 television in the UK, Paraguay’s Painful Harvest, described how the industrial farming of GM RR soy had led to violent clashes between peasant farmers (campesinos), foreign landowners and the police.[158]

Some displaced peasant farmers are trying to regain control of land through “land invasions”.[159] According to the Pulitzer Center on Crisis Reporting, the Paraguay government has used the military to quash land invasions.[160]

CONCLUSION

The cultivation of GM RR soy endangers human and animal health, increases herbicide use, damages the environment, and has negative impacts on rural populations. The monopolistic control by agribusiness companies over GM RR soy technology and production endangers markets, compromises the economic viability of farming, and threatens food security.

In light of these impacts, it is misleading to describe GM RR soy production as sustainable and responsible. To do so sends a confusing message to consumers and all in the supply chain, interfering with their ability to identify products that reflect their needs and values.

Proponents of GM RR soy are invited to address the arguments and scientific findings in this paper and to join in a transparent, science-based inquiry into the principles of sustainability and soy production.

REFERENCES

1: ISAAA Brief 37-2007: Global status of commercialized biotech/GM crops: 2007. http://www.isaaa.org/resources/publications/briefs/37/executivesummary/default.html
2: Bindraban, P.S., Franke. A.C. Ferrar, D.O., Ghersa, C.M., Lotz, L.A.P., Nepomuceno, A., Smulders, M.J.M., van de Wiel, C.C.M. 2009. GM-related sustainability: agro-ecological impacts, risks and opportunities of soy production in Argentina and Brazil, Plant Research International, Wageningen UR, Wageningen, the Netherlands, Report 259. http://gmsoydebate.global-connections.nl/sites/gmsoydebate.global-connections.nl/files/library/2009%20WUR%20Research%20Report%20GM%20Soy.pdf
3: Round Table on Responsible Soy Association. 2010. RTRS standard for responsible soy production. Version 1.0, June. http://www.responsiblesoy.org/
4: ISAAA. 2010. ISAAA Brief 41-2009: Press release. February 3. http://www.isaaa.org/resources/publications/briefs/41/pressrelease/default.asp
5: GMO Compass. 2010. Genetically modified plants: Global cultivation on 134 million hectares. March 29. http://bit.ly/9MDULS
6: Benachour, N., Séralini, G-E. 2009. Glyphosate formulations induce apoptosis and necrosis in human umbilical, embryonic, and placental cells. Chem. Res. Toxicol. 22, 97–105.
7: Gasnier, C., Dumont, C., Benachour, N., Clair, E., Chagnon, M.C., Séralini, G-E. 2009. Glyphosate-based herbicides are toxic and endocrine disruptors in human cell lines. Toxicology 262, 184-191.
8: Richard, S., Moslemi, S., Sipahutar, H., Benachour, N., Séralini, G-E. 2005. Differential effects of glyphosate and Roundup on human placental cells and aromatase. Environmental Health Perspectives 113, 716–20.
9: Haefs, R., Schmitz-Eiberger, M., Mainx, H.G., Mittelstaedt, W., Noga, G. 2002. Studies on a new group of biodegradable surfactants for glyphosate. Pest Manag. Sci. 58, 825–833.
10: Marc, J., Mulner-Lorillon, O., Boulben, S., Hureau, D., Durand, G., Bellé, R. 2002. Pesticide Roundup provokes cell division dysfunction at the level of CDK1/cyclin B activation. Chem Res Toxicol. 15, 326–31.
11: Benachour, N., Sipahutar, H., Moslemi, S., Gasnier, C., Travert, C., Séralini, G-E. 2007. Time- and dose-dependent effects of roundup on human embryonic and placental cells. Archives of Environmental Contamination and Toxicology 53, 126–33.
12: Relyea, R.A. 2005. The impact of insecticides and herbicides on the biodiversity and productivity of aquatic communities. Ecol. Appl. 15, 618–627
13: Relyea, R.A., Schoeppner, N. M., Hoverman, J.T. 2005. Pesticides and amphibians: the importance of community context. Ecological Applications 15, 1125–1134.
14: Marc, J., Mulner-Lorillon, O., Bellé, R. 2004. Glyphosate-based pesticides affect cell cycle regulation. Biology of the Cell 96, 245–249.
15: Bellé, R., Le Bouffant, R., Morales, J., Cosson, B., Cormier, P., Mulner-Lorillon, O. 2007. Sea urchin embryo, DNA-damaged cell cycle checkpoint and the mechanisms initiating cancer development. J. Soc. Biol. 201, 317–327.
16: Marc, J., Mulner-Lorillon, O., Boulben, S., Hureau, D., Durand, G., Bellé, R. 2002. Pesticide Roundup provokes cell division dysfunction at the level of CDK1/cyclin B activation. Chem. Res Toxicol. 15, 326–331.
17: Marc, J., Bellé, R., Morales, J., Cormier, P., Mulner-Lorillon, O. 2004. Formulated glyphosate activates the DNA-response checkpoint of the cell cycle leading to the prevention of G2/M transition. Toxicological Sciences 82, 436–442.
18: Dallegrave, E., Mantese, F.D., Coelho, R.S., Pereira, J.D., Dalsenter, P.R., Langeloh, A. 1993. The teratogenic potential of the herbicide glyphosate-Roundup in Wistar rats. Toxicol. Lett. 142, 45-52.
19: Mañas, F., Peralta, L., Raviolo, J., Garcia Ovando, H., Weyers, A., Ugnia, L., Gonzalez Cid, M., Larripa, I., Gorla, N. 2009. Genotoxicity of AMPA, the environmental metabolite of glyphosate, assessed by the Comet assay and cytogenetic tests. Ecotoxicology and Environmental Safety 72, 834–837.
20: Carrasco is director of the Laboratory of Molecular Embryology, University of Buenos Aires Medical School and lead researcher of the National Council of Scientific and Technical Research (CONICET), Argentina.
21: Paganelli, A., Gnazzo, V., Acosta, H., López, S.L., Carrasco, A.E. 2010. Glyphosate-based herbicides produce teratogenic effects on vertebrates by impairing retinoic acid signalling. Chem. Res. Toxicol., August 9. http://pubs.acs.org/doi/abs/10.1021/tx1001749
22: Carrasco, A. 2010. Interview with journalist Dario Aranda, August.
23: Teubal, M., Domínguez, D., Sabatino, P. 2005. Transformaciones agrarias en la argentina. Agricultura industrial y sistema agroalimentario. In: El campo argentino en la encrucijada. Estrategias y resistencias sociales, ecos en la ciudad. Giarracca, N., Teubal, M., eds., Buenos Aires: Alianza Ed.ial, 37–78.
24: Teubal, M. 2009. Expansión del modelo sojero en la Argentina. De la producción de alimentos a los commodities. In: La persistencia del campesinado en América Latina (Lizarraga, P., Vacaflores, C., eds., Comunidad de Estudios JAINA, Tarija, 161–197.
25: Webber, J., Weitzman, H. 2009. Argentina pressed to ban crop chemical after health concerns. Financial Times, May 29. http://www.gene.ch/genet/2009/Jun/msg00006.html
26: FAO. Pesticide residues in food – 1997: Report. Report of the Joint Meeting of the FAO Panel of Experts on Pesticide Residues in Food and the Environment and the WHO Core Assessment Group on Pesticide Residues. Lyons, France, 22 September – 1 October 1997. http://www.fao.org/docrep/w8141e/w8141e0u.htm
27: Webber, J., Weitzman, H. 2009. Argentina pressed to ban crop chemical after health concerns. Financial Times, May 29. http://www.gene.ch/genet/2009/Jun/msg00006.html
28: Romig, S. 2010. Argentina court blocks agrochemical spraying near rural town. Dow Jones Newswires, March 17. http://bit.ly/cg2AgG
29: Comision Provincial de Investigación de Contaminantes del Agua. 2010. Primer informe. Resistencia, Chaco. April.
30: Aranda, D. 2010. La salud no es lo primero en el modelo agroindustrial. Pagina12, June 14. http://www.pagina12.com.ar/diario/elpais/1-147561-2010-06-14.html
31: Amnesty International. 2010. Argentina: Threats deny community access to research. 12 August. http://bit.ly/cJsqUR
32: Savitz, D.A., Arbuckle, T., Kaczor, D., Curtis, K.M. 1997. Male pesticide exposure and pregnancy outcome. Am. J. Epidemiol. 146, 1025–1036.
33: De Roos, A.J., Blair, A., Rusiecki, J.A., Hoppin, J.A., Svec, M., Dosemeci, M., Sandler, D.P., Alavanja, M.C. 2005. Cancer incidence among glyphosate-exposed pesticide applicators in the Agricultural Health Study. Environ Health Perspect. 113, 49–54.
34: Hardell, L., Eriksson, M. A. 1999. Case-control study of non-Hodgkin lymphoma and exposure to pesticides. Cancer 85, 1353–60.
35: Hardell, L., Eriksson, M., Nordstrom, M. 2002. Exposure to pesticides as risk factor for non-Hodgkin's lymphoma and hairy cell leukemia: Pooled analysis of two Swedish case-control studies. Leuk Lymphoma 43, 1043-9.
36: Paz-y-Miño, C., Sánchez, M.E., Arévalo, M., Muñoz, M.J., Witte, T., De-la-Carrera, G.O., Leone, P. E. 2007. Evaluation of DNA damage in an Ecuadorian population exposed to glyphosate. Genetics and Molecular Biology 30, 456-460.
37: Viehweger, G., Danneberg, H. 2005. Glyphosat und Amphibiensterben? Darstellung und Bewertung des Sachstandes. Sächsische Landesanstalt für Landwirtschaft.
38: FAO. 2005. Pesticide residues in food – 2005. Evaluations, Part I: Residues (S. 477). http://www.fao.org/docrep/009/a0209e/a0209e0d.htm
39: Schuette, J. 1998. Environmental fate of glyphosate. Environmental Monitoring & Pest Management, Dept of Pesticide Regulation, Sacramento, CA. http://www.cdpr.ca.gov/docs/empm/pubs/fatememo/glyphos.pdf
40: Santillo, D.J., Brown, P.W., Leslie, D.M. 1989. Response of songbirds to glyphosate-induced habitat changes on clearcuts. J. Wildlife Management 53, 64–71.
41: Springett, J.A., Gray, R.A.J. 1992. Effect of repeated low doses of biocides on the earthworm Aporrectodea caliginosa in laboratory culture. Soil Biol. Biochem. 24, 1739–1744.
42: World Health Organisation (WHO). 1994. Glyphosate. Environmental Health Criteria 159. The International Programme on Chemical Safety (IPCS). WHO, Geneva.
43: Attorney General of the State of New York, Consumer Frauds and Protection Bureau, Environmental Protection Bureau. 1996. In the matter of Monsanto Company, respondent. Assurance of discontinuance pursuant to executive law § 63(15). New York, NY, Nov. False advertising by Monsanto regarding the safety of Roundup herbicide (glyphosate). http://www.mindfully.org/Pesticide/Monsanto-v-AGNYnov96.htm
44: Monsanto fined in France for "false" herbicide ads. Agence France Presse, Jan 26, 2007, http://www.organicconsumers.org/articles/article_4114.cfm
45: Key FDA documents, including statements from FDA scientists on the risks of GM foods, have been obtained by the Alliance for Biointegrity and are available at: http://www.biointegrity.org/list.html
46: US FDA. 1995. Biotechnology Consultation Agency Response Letter BNF No. 000001. January 27. http://www.fda.gov/Food/Biotechnology/Submissions/ucm161129.htm
47: Then, C., Potthof, C. 2009. Risk Reloaded: Risk analysis of genetically engineered plants within the European Union. Testbiotech e.V., Institute for Independent Impact Assessment in Biotechnology. http://www.testbiotech.org/sites/default/files/risk-reloaded_engl.pdf
48: Latham, J.R. Wilson, A.K., Steinbrecher, R.A. 2006. The mutational consequences of plant transformation. J. of Biomedicine and Biotechnology 2006, 1–7.
49: Wilson, A.K., Latham, J.R., Steinbrecher, R.A. 2006. Transformation-induced mutations in transgenic plants: Analysis and biosafety implications. Biotechnology and Genetic Engineering Reviews 23, 209–234.
50: Séralini, G.-E., Cellier, D., de Vendomois, J.S. 2007. New analysis of a rat feeding study with a genetically modified maize reveals signs of hepatorenal toxicity. Arch. Environ Contam Toxicol. 52, 596–602.
51: Kilic, A., Akay, M.T. 2008. A three generation study with genetically modified Bt corn in rats: Biochemical and histopathological investigation. Food and Chemical Toxicology 46, 1164–1170.
52: Finamore, A., Roselli, M., Britti, S., Monastra, G., Ambra, R., Turrini, A., Mengheri, E. 2008. Intestinal and peripheral immune response to MON810 maize ingestion in weaning and old mice. J. Agric. Food Chem. 56, 11533–11539.
53: Velimirov, A., Binter, C., Zentek, J. 2008. Biological effects of transgenic maize NK603xMON810 fed in long term reproduction studies in mice. Bundesministerium für Gesundheit, Familie und Jugend Report, Forschungsberichte der Sektion IV Band 3/2008, Austria.
54: US Food and Drug Administration. 2002. Biotechnology Consultation Note to the File BNF No 00077. Office of Food Additive Safety, Center for Food Safety and Applied Nutrition, US Food and Drug Administration, September 4.
55: Do seed companies control GM crop research? Editorial, Scientific American, August 2009. http://www.scientificamerican.com/article.cfm?id=do-seed-companies-control-gm-crop-research
56: Waltz, E. 2009. Biotech proponents aggressively attack independent research papers: GM crops: Battlefield. Nature 461, 27–32.
57: Quist, D., Chapela, I. 2001. Transgenic DNA introgressed into traditional maize landraces in Oaxaco, Mexico. Nature 414, November 29, 541.
58: Rowell, A. 2003. Immoral maize. In: Don't Worry, It's Safe to Eat. Earthscan Ltd. Reprinted: http://bit.ly/1pi26N
59: Monbiot, G. 2002. The fake persuaders. The Guardian, May 14. http://www.monbiot.com/archives/2002/05/14/the-fake-persuaders/
60: Malatesta, M., Biggiogera, M., Manuali, E., Rocchi. M.B., Baldelli, B., Gazzanelli, G. 2003. Fine structural analysis of pancreatic acinar cell nuclei from mice fed on GM soybean. Eur J Histochem. 47, 385–8.
61: Malatesta, M., Caporaloni, C., Gavaudan, S., Rocchi, M.B., Serafini, S., Tiberi, C., Gazzanelli, G. 2002. Ultrastructural morphometrical and immunocytochemical analyses of hepatocyte nuclei from mice fed on genetically modified soybean. Cell Struct Funct. 27, 173–180.
62: Vecchio, L., Cisterna, B., Malatesta, M., Martin, T.E., Biggiogera, M. 2004. Ultrastructural analysis of testes from mice fed on genetically modified soybean. Eur J Histochem. 48, 448–454.
63: Malatesta, M., Boraldi, F., Annovi, G., Baldelli, B., Battistelli, S., Biggiogera, M., Quaglino, D. 2008. A long-term study on female mice fed on a genetically modified soybean: effects on liver ageing. Histochem Cell Biol. 130, 967–77.
64: Tudisco, R., Lombardi, P., Bovera, F., d'Angelo, D., Cutrignelli, M. I., Mastellone, V., Terzi, V., Avallone, L., Infascelli, F. 2006. Genetically modified soya bean in rabbit feeding: detection of DNA fragments and evaluation of metabolic effects by enzymatic analysis. Animal Science 82, 193–199.
65: Brasil, F.B., Soares, L.L., Faria, T.S., Boaventura, G.T., Sampaio, F.J., Ramos, C.F. 2009. The impact of dietary organic and transgenic soy on the reproductive system of female adult rat. Anat Rec (Hoboken) 292, 587–94.
66: Russia says genetically modified foods are harmful. Voice of Russia, April 16, 2010. http://english.ruvr.ru/2010/04/16/6524765.html
67: Schubbert, R., Hohlweg, U., Renz, D., Doerfler, W. 1998. On the fate of orally ingested foreign DNA in mice: chromosomal association and placental transmission to the fetus, Molecular Genetics and Genomics 259, 569–76.
68: Agodi, A., Barchitta, M., Grillo, A., Sciacca, S. 2006. Detection of genetically modified DNA sequences in milk from the Italian market. Int J Hyg Environ Health 209, 81–88.
69: Tudisco, R., Mastellone, V., Cutrignelli, M.I, Lombardi, P, Bovera, F., Mirabella, N., Piccolo, G., Calabro, S., Avallone, L., Infascelli, F. 2010. Fate of transgenic DNA and evaluation of metabolic effects in goats fed genetically modified soybean and in their offsprings. Animal.
70: Benbrook C. 1999. Evidence of the magnitude and consequences of the Roundup Ready soybean yield drag from university-based varietal trials in 1998. Ag BioTech InfoNet Technical Paper No 1, Jul 13. http://www.mindfully.org/GE/RRS-Yield-Drag.htm
71: Elmore R.W., Roeth, F.W., Nelson, L.A., Shapiro, C.A., Klein, R.N., Knezevic, S.Z., Martin, A. 2001. Glyphosate-resistant soyabean cultivar yields compared with sister lines. Agronomy Journal 93, 408–412.
72: Qaim, M. and G. Traxler. 2005. Roundup Ready soybeans in Argentina: farm level and aggregate welfare effects. Agricultural Economics 32, 73–86.
73: Kaskey, J. 2009. Monsanto facing "distrust" as it seeks to stop DuPont. Bloomberg, November 11.
74: Gillam, C. 2010. Virginia probing Monsanto soybean seed pricing. West Virginia investigating Monsanto for consumer fraud. Reuters, June 25. http://www.reuters.com/article/idUSN2515475920100625
75: Nandula V.K., Reddy, K., Duke, S. 2005. Glyphosate-resistant weeds: Current status and future outlook. Outlooks on Pest Management 16, 183–187.
76: Syngenta module helps manage glyphosate-resistant weeds. Delta Farm Press, 30 May 2008, http://deltafarmpress.com/mag/farming_syngenta_module_helps/index.html
77: Robinson, R. 2008. Resistant ryegrass populations rise in Mississippi. Delta Farm Press, Oct 30. http://deltafarmpress.com/wheat/resistant-ryegrass-1030/
78: Johnson, B. and Davis, V. 2005. Glyphosate resistant horseweed (marestail) found in 9 more Indiana counties. Pest & Crop, May 13. http://extension.entm.purdue.edu/pestcrop/2005/issue8/index.html#marestail
79: Nice, G, Johnson, B., Bauman, T. 2008. A little burndown madness. Pest & Crop, 7 March. http://extension.entm.purdue.edu/pestcrop/2008/issue1/index.html#burndown
80: Fall applied programs labeled in Indiana. Pest & Crop 23, 2006. http://extension.entm.purdue.edu/pestcrop/2006/issue23/table1.html
81: Randerson, J. 2002. Genetically-modified superweeds "not uncommon". New Scientist, 05 February. http://www.newscientist.com/article/dn1882-geneticallymodified-superweeds-not-uncommon.html
82: Royal Society of Canada. 2001. Elements of precaution: Recommendations for the regulation of food biotechnology in Canada. An expert panel report on the future of food biotechnology prepared by the Royal Society of Canada at the request of Health Canada Canadian Food

Inspection Agency and Environment Canada. http://www.rsc.ca//files/publications/expert_panels/foodbiotechnology/GMreportEN.pdf
83: Knispel A.L., McLachlan, S.M., Van Acker, R., Friesen, L.F. 2008. Gene flow and multiple herbicide resistance in escaped canola populations. Weed Science 56, 72–80.
84: Herbicide Resistance Action Committee. Glycines (G/9) resistant weeds by species and country. www.weedscience.org. http://www.weedscience.org/Summary/UspeciesMOA.asp?lstMOAID=12&FmHRACGroup=Go
85: Vila-Aiub, M.M., Vidal. R.A., Balbi, M.C., Gundel, P.E., Trucco, F., Ghersa, C.M. 2007. Glyphosate-resistant weeds of South American cropping systems: an overview. Pest Management Science, 64, 366–371.
86: Branford S. 2004. Argentina's bitter harvest. New Scientist, 17 April.
87: Benbrook C.M. 2005. Rust, resistance, run down soils, and rising costs – Problems facing soybean producers in Argentina. AgBioTech InfoNet, Technical Paper No 8, January.
88: Benbrook, C.M. 2009. Impacts of genetically engineered crops on pesticide use in the United States: The first thirteen years. The Organic Center, November. http://www.organic-center.org/reportfiles/13Years20091126_FullReport.pdf
89: Bindraban, P.S., Franke. A.C. Ferrar, D.O., Ghersa, C.M., Lotz, L.A.P., Nepomuceno, A., Smulders, M.J.M., van de Wiel, C.C.M. 2009. GM-related sustainability: agro-ecological impacts, risks and opportunities of soy production in Argentina and Brazil, Plant Research International, Wageningen UR, Wageningen, the Netherlands, Report 259. http://gmsoydebate.global-connections.nl/sites/gmsoydebate.global-connections.nl/files/library/2009%20WUR%20Research%20Report%20GM%20Soy.pdf
90: Gustin, G. 2010. Roundup's potency slips, foils farmers. St. Louis Post-Dispatch, July 25. http://www.soyatech.com/news_story.php?id=19495
91: GMO Compass. 2010. Field areas 2009. Genetically modified plants: Global cultivation on 134 million hectares. March 29. http://bit.ly/9MDULS
92: GMO Compass. 2009. USA: Cultivation of GM plants, 2009. http://bit.ly/deYADq
93: Benbrook, C.M. 2009. Impacts of genetically engineered crops on pesticide use in the United States: The first thirteen years. The Organic Center, November. http://www.organic-center.org/reportfiles/13Years20091126_FullReport.pdf
94: Benbrook, C.M. 2009. Impacts of genetically engineered crops on pesticide use in the United States: The first thirteen years. The Organic Center, November. http://www.organic-center.org/reportfiles/13Years20091126_FullReport.pdf
95: Monsanto. 2008. Conversations about plant biotechnology: Argentina. http://www.monsanto.com/biotech-gmo/asp/farmers.asp?cname=Argentina&id=RodolfoTosar
96: Benbrook C.M. 2005. Rust, resistance, run down soils, and rising costs – Problems facing soybean producers in Argentina. AgBioTech InfoNet, Technical Paper No 8, January.
97: Pengue, W. 2003. El glifosato y la dominación del ambiente. Biodiversidad 37, July. http://www.grain.org/biodiversidad/?id=208
98: Benbrook C.M. 2005. Rust, resistance, run down soils, and rising costs – Problems facing soybean producers in Argentina. AgBioTech InfoNet, Technical Paper No 8, January.
99: Benbrook C.M. 2005. Rust, resistance, run down soils, and rising costs – Problems facing soybean producers in Argentina. AgBioTech InfoNet, Technical Paper No 8, January.
100: Oda, L., 2010. GM technology is delivering its promise. Brazilian Biosafety Association, June 14. http://www.scidev.net/en/editor-letters/gm-technology-is-delivering-its-promise.html
101: Benbrook C.M. 2005. Rust, resistance, run down soils, and rising costs – Problems facing soybean producers in Argentina. AgBioTech InfoNet, Technical Paper No 8, January. http://www.greenpeace.org/raw/content/denmark/press/rapporter-og-dokumenter/rust-resistance-run-down-soi.pdf
102: Pengue, W.A. 2005. Transgenic crops in Argentina: the ecological and social debt. Bulletin of Science, Technology and Society 25, 314-322. http://bch.biodiv.org/database/attachedfile.aspx?id=1538
103: Altieri, M.A., Pengue, W.A. 2005. Roundup ready soybean in Latin America: a machine of hunger, deforestation and socio-ecological devastation. RAP-AL Uruguay. http://webs.chasque.net/~rapaluy1/transgenicos/Prensa/Roundupready.html
104: Ventimiglia, L. 2003. El suelo, una caja de ahorros que puede quedar sin fondos [Land, saving box that might lose its capital]. La Nación, October 18, 7.
105: Benbrook C.M. 2005. Rust, resistance, run down soils, and rising costs – Problems facing soybean producers in Argentina. AgBioTech InfoNet, Technical Paper No 8, January.
106: Altieri, M.A., Pengue, W.A. 2005. Roundup ready soybean in Latin America: a machine of hunger, deforestation and socio-ecological devastation. RAP-AL Uruguay. http://webs.chasque.net/~rapaluy1/transgenicos/Prensa/Roundupready.html
107: Strautman, B. 2007. Manganese affected by glyphosate. Western Producer. http://www.gefreebc.org/gefree_tmpl.php?content=manganese_glyphosate
108: Zobiole L.H.S., Oliveira R.S., Visentainer J.V., Kremer R.J., Bellaloui N., Yamada T. 2010. Glyphosate affects seed composition in glyphosate-resistant soybean. J. Agric. Food Chem. 58, 4517–4522.
109: King, A.C., Purcell, L.C., Vories, E.D. 2001. Plant growth and nitrogenase activity of glyphosate-tolerant soybean in response to foliar glyphosate applications. Agronomy Journal 93, 179–186.
110: Scientist warns of dire consequences with widespread use of glyphosate. The Organic and Non-GMO Report, May 2010. http://www.non-gmoreport.com/articles/may10/consequenceso_widespread_glyphosate_use.php
111: Huber, D.M., Cheng, M.W., and Winsor, B.A. 2005. Association of severe Corynespora root rot of soybean with glyphosate-killed giant ragweed. Phytopathology 95, S45.
112: Huber, D.M., and Haneklaus, S. 2007. Managing nutrition to control plant disease. Landbauforschung Volkenrode 57, 313–322.
113: Sanogo S, Yang, X., Scherm, H. 2000. Effects of herbicides on Fusarium solani f. sp. glycines and development of sudden death syndrome in glyphosate-tolerant soybean. Phytopathology 2000, 90, 57–66.
114: University of Missouri. 2000. MU researchers find fungi buildup in glyphosate-treated soybean fields. University of Missouri, 21 December. http://www.biotech-info.net/fungi_buildup.html
115: Kremer, R.J., Means, N.E. 2009. Glyphosate and glyphosate-resistant crop interactions with rhizosphere microorganisms. European Journal of Agronomy 31, 153–161.
116: Kremer, R.J., Means, N.E., Kim, S. 2005. Glyphosate affects soybean root exudation and rhizosphere microorganisms. Int. J. of Analytical Environmental Chemistry 85, 1165–1174.
117: Fernandez, M.R., Zentner, R.P., Basnyat, P., Gehl, D., Selles, F., Huber, D., 2009. Glyphosate associations with cereal diseases caused by Fusarium spp. in the Canadian prairies. Eur. J. Agron. 31, 133–143.
118: Fernandez, M.R., Zentner, R.P., DePauw, R.M., Gehl, D., Stevenson, F.C., 2007. Impacts of crop production factors on common root rot of barley in Eastern Saskatchewan. Crop Sci. 47, 1585–1595.
119: Scientist warns of dire consequences with widespread use of glyphosate. The Organic and Non-GMO Report, May 2010. http://www.non-gmoreport.com/articles/may10/consequenceso_widespread_glyphosate_use.php
120: Johal, G.S., Huber, D.M. 2009. Glyphosate effects on diseases of plants. Europ. J. Agronomy 31, 144–152.
121: Bindraban, P.S., Franke. A.C. Ferrar, D.O., Ghersa, C.M., Lotz, L.A.P., Nepomuceno, A., Smulders, M.J.M., van de Wiel, C.C.M. 2009. GM-related sustainability: agro-ecological impacts, risks and opportunities of soy production in Argentina and Brazil, Plant Research International, Wageningen UR, Wageningen, the Netherlands, Report 259. http://gmsoydebate.global-connections.nl/sites/gmsoydebate.global-connections.nl/files/library/2009%20WUR%20Research%20Report%20GM%20Soy.pdf
122: Kfir, R., Van Hamburg, H., van Vuuren, R. 1989. Effect of stubble treatment on the post-diapause emergence of the grain sorghum stalk borer, Chilo partellus (Swinhoe) (Lepidoptera: Pyralidae). Crop Protection 8, 289-292.
123: Bianco, R. 1998. Ocorrência e manejo de pragas. In Plantio Direto. Pequena propriedade sustentável. Instituto Agronômico do Paraná (IAPAR) Circular 101, Londrina, PR, Brazil, 159–172.
124: Forcella, F., Buhler, D.D. and McGiffen, M.E. 1994. Pest management and crop residues. In Crops Residue Management. Hatfield, J.L. and Stewart, B.A. Ann Arbor, MI, Lewis,173–189.
125: Nazareno, N. 1998. Ocorrência e manejo de doenças. In Plantio Direto. Pequena proprie dade sustentável. Instituto Agronômico do Paraná (IAPAR) Circular 101, Londrina, PR, Brasil, 173–190.
126: Scopel, E., Triomphe, B., Ribeiro, M. F. S., Séguy, L., Denardin, J. E., and Kochann, R. A. 2004. Direct seeding mulch-based cropping systems (DMC) in Latin America. In New Directions for a Diverse Planet: Proceedings for the 4th International Crop Science Congress, Brisbane, Australia, September 26– October 1, 2004. T. Fischer, N. Turner, J. Angus, L. McIntyre, M. Robertsen, A. Borrell, and D. Lloyd, Eds. http://www.cropscience.org.au
127: Bolliger, A., Magid, J., Carneiro, J., Amado, T., Neto, F.S., de Fatima dos Santos Ribeiro, M., Calegari, A., Ralisch, R., de Neergaard, A. 2006. Taking stock of the Brazilian "zero-till revolution": A Review of landmark research and farmers' practice. Advances in Agronomy, Vol. 91, pages 49-111.
128: Fernandez, M.R., Zentner, R.P., Basnyat, P., Gehl, D., Selles, F., Huber, D., 2009. Glyphosate associations with cereal diseases caused by Fusarium spp. in the Canadian prairies. Eur. J. Agron. 31, 133–143.
129: Bindraban, P.S., Franke. A.C. Ferrar, D.O., Ghersa, C.M., Lotz, L.A.P., Nepomuceno, A., Smulders, M.J.M., van de Wiel, C.C.M. 2009. GM-related sustainability: agro-ecological impacts, risks and opportunities of soy production in Argentina and Brazil, Plant Research International, Wageningen UR, Wageningen, the Netherlands, Report 259. http://gmsoydebate.global-connections.nl/sites/gmsoydebate.global-connections.nl/files/library/2009%20WUR%20Research%20Report%20GM%20Soy.pdf
130: Bindraban and colleagues acknowledge in their study that their findings run counter to those of an earlier paper by Brookes and Barfoot (Brookes, G. & Barfoot, P. 2006. GM crops: the first ten years – global socio-economic and environmental impacts. ISAAA Brief no. 36), which found a small decrease in field EIQ when RR soy is adopted. However, Brookes and Barfoot used different sources of data – Kynetic, AAPRESID and Monsanto Argentina, whereas Bindraban and colleagues used the agricultural journal AGROMERCADO as their source. Brookes and Barfoot's data sources give lower glyphosate and 2,4-D application rates. Brookes and Barfoot are not scientists but run a PR company (PG Economics) that works for biotech companies, and their paper was written for the industry lobby group ISAAA. There is no indication that it was peer-reviewed.
131: Baker J.M., Ochsner T.E., Venterea R.T., Griffis T.J. 2007. Tillage and soil carbon sequestration – What do we really know? Agriculture, Ecosystems and Environment 118, 1–5.
132: Bindraban, P.S., Franke. A.C. Ferrar, D.O., Ghersa, C.M., Lotz, L.A.P., Nepomuceno, A., Smulders, M.J.M., van de Wiel, C.C.M. 2009. GM-related sustainability: agro-ecological impacts, risks and opportunities of soy production in Argentina and Brazil. Plant Research International, Wageningen UR, Wageningen, the Netherlands, Report 259. http://gmsoydebate.global-connections.nl/sites/gmsoydebate.global-connections.nl/files/library/2009%20WUR%20Research%20Report%20GM%20Soy.pdf
133: ISAAA Brief 37-2007: Global status of commercialized biotech/GM crops: 2007. http://www.isaaa.org/resources/publications/briefs/37/executivesummary/default.html
134: US Department of Agriculture (USDA) Foreign Agriculture Service. 2010. Gap shrinks between global soybean production and consumption. Oilseeds: World Markets and Trade. FOP-05-10, May.
135: Benbrook, C.M. 2005. Rust, resistance, run down soils, and rising costs – Problems facing soybean producers in Argentina. AgBioTech InfoNet Technical Paper Number 8, January.
136: Raszewski, E. 2010. Soybean invasion sparks move in Argentine Congress to cut wheat export tax. Bloomberg, August 18. http://bit.ly/bvfqFQ
137: Valente, M. 2008. Soy – High profits now, hell to pay later. IPS, July 29. http://ipsnews.net/news.asp?idnews=43353
138: Pengue, W. 2005. Transgenic crops in Argentina: the ecological and social debt. Bulletin of Science, Technology and Society 25, 314–322. http://bch.biodiv.org/database/attachedfile.aspx?id=1538
139: Pengue, W. 2005. Transgenic crops in Argentina: the ecological and social debt. Bulletin of Science, Technology and Society 25, 314–322. http://bch.biodiv.org/database/attachedfile.aspx?id=1538
140: INDEC (Instituto Nacional de Estadistica y Censos). 2004. Pobreza. http://www.indec.gov.ar/. Cited in Benbrook C.M. 2005. Rust, resistance, run down soils, and rising costs – Problems facing soybean producers in Argentina. AgBioTech InfoNet, Technical Paper No 8, January.
141: Gudynas, E. 2007. Perspectivas de la producción sojera 2006/07. Montevideo: CLAES. http://www.agropecuaria.org/observatorio/OASOGudynasReporteSoja2006a07.pdf
142: Giarracca, N., Teubal, M. 2006. Democracia y neoliberalismo en el campo Argentino. Una convivencia difícil. In La Construcción de la Democracia en el Campo Latinoamericano. Buenos Aires: CLACSO.
143: Fernandez-Cornejo, J., Klotz-Ingram, C., Jans, S. 2002. Farm-level effects of adopting herbicide-tolerant soybeans in the USA, Journal of Agricultural and Applied Economics 34, 149–163.
144: Bullock, D., Nitsi, E.I. 2001. GMO adoption and private cost savings: GR soybeans and Bt corn. In Gerald C. Nelson: GMOs in agriculture: economics and politics, Urbana, USA, Academic Press, 21-38.
145: Gómez-Barbero, M., Rodríguez-Cerezo, E. 2006. Economic impact of dominant GM crops worldwide: a review. European Commission Joint Research Centre: Institute for Prospective Technological Studies. December.
146: Benbrook, C.M. 2009. The magnitude and impacts of the biotech and organic seed price premium. The Organic Center, December. http://www.organic-center.org/reportfiles/Seeds_Final_11-30-09.pdf
147: Neuman, W. 2010. Rapid rise in seed prices draws US scrutiny. New York Times, March 11. http://www.nytimes.com/2010/03/12/business/12seed.html
148: Kirchgaessner, S. 2010. DOJ urged to complete Monsanto case. Financial Times, August 9. http://www.organicconsumers.org/articles/article_21384.cfm
149: Pollack, C. 2009. Interest in non-genetically modified soybeans growing. Ohio State University Extension, April 3. http://extension.osu.edu/~news/story.php?id=5099
150: Jones, T. 2008. Conventional soybeans offer high yields at lower cost. University of Missouri, Sept. 8. http://agebb.missouri.edu/news/ext/showall.asp?story_num=4547&iln=49
151: Medders, H. 2009. Soybean demand may rise in conventional state markets. University of Arkansas, Division of Agriculture, March 20. http://www.stuttgartdailyleader.com/homepage/x599206227/Soybean-demand-may-rise-in-conventional-state-markets
152: Biggest Brazil soy state loses taste for GMO seed. Reuters, March 13, 2009. http://www.reuters.com/article/internal_ReutersNewsRoom_BehindTheScenes_MOLT/idUSTRE52C5AB20090313
153: Macedo, D. 2010. Agricultores reclamam que Monsanto restringe acesso a sementes de soja convencional (Farmers complain that Monsanto restricts access to conventional soybean seeds). Agencia Brasil, May 18. http://is.gd/chytI. English translation: http://www.gmwatch.org/index.php?option=com_content&view=article&id=12237
154: Blue E.N. 2007. Risky business. Economic and regulatory impacts from the unintended release of genetically engineered rice varieties into the rice merchandising system of the US. Greenpeace International. http://www.greenpeace.org/raw/content/international/press/reports/risky-business.pdf
155: Fisk, M.C., Whittington, J. 2010. Bayer loses fifth straight trial over US rice crops. Bloomberg Businessweek, July 14. http://www.businessweek.com/news/2010-07-14/bayer-loses-fifth-straight-trial-over-u-s-rice-crops.html
156: Schmitz, T.G., Schmitz, A., Moss, C.B. 2005. The economic impact of StarLink corn. Agribusiness 21, 391–407.
157: ISAAA Brief 39. Global status of commercialized biotech/GM crops: 2008.
158: Paraguay's Painful Harvest. Unreported World. 2008. Episode 14. First broadcast on Channel 4 TV, UK, November 7. http://www.channel4.com/programmes/unreported-world/episode-guide/series-2008/episode-14/
159: Abramson, E. 2009. Soy: A hunger for land. North American Congress on Latin America (NACLA) Report on the Americas 42, May/June. https://nacla.org/soyparaguay
160: Lane, C. 2010. Paraguay. The soybean wars. Pulitzer Center on Crisis Reporting. http://pulitzergateway.org/2008/04/the-soybean-wars-overview/

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About the authors and publishers of GM Soy: Sustainable? Responsible?

This report was compiled by an international coalition of scientists who hold the view that the complete body of evidence on GM soy and glyphosate herbicide should be made accessible to everyone – government, industry, the media, and the public. The scientists and their contact details are as follows:

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