

# TWENTY YEARS OF FAILURE

WHY GM CROPS HAVE FAILED TO DELIVER ON THEIR  
PROMISES

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November 2015

**GREENPEACE**

## Seven myths about GM crops, and the truth behind them

### **MYTH 1:** GM crops can feed the world

**REALITY:** There are no GM crops designed to deliver high yields. Genetic engineering is ill-adapted to solve the problems underpinning hunger and malnutrition - it reinforces the industrial agriculture model that has failed to feed the world so far.

### **MYTH 2:** GM crops hold the key to climate resilience

**REALITY:** Genetic engineering lags behind conventional breeding in developing plant varieties that can help agriculture cope with climate change. Climate resilience heavily depends on farming practices promoting diversity and nurturing the soil, not on the over-simplified farming system GM crops are designed for.

### **MYTH 3:** GM crops are safe for humans and the environment

**REALITY:** Long term environmental and health monitoring programmes either do not exist or are inadequate. Independent researchers complain that they are denied access to material for research.

### **MYTH 4:** GM crops simplify crop protection

**REALITY:** After a few years, problems such as herbicide-resistant weeds and super-pests emerge in response to herbicide tolerant and insect resistant GM crops, resulting in the application of additional pesticides.

### **MYTH 5:** GM crops are economically viable for farmers

**REALITY:** GM seed prices are protected by patents and their prices have soared over the last 20 years. The emergence of herbicide-resistant weeds and super-pests increases farmers' costs, reducing their economic profits even further.

### **MYTH 6:** GM crops can coexist with other agricultural systems

**REALITY:** GM crops contaminate non-GM crops. Nearly 400 incidents of GM contamination have been recorded globally so far. Staying GM-free imposes considerable additional, and sometimes impossible, costs for farmers.

### **MYTH 7:** Genetic engineering is the most promising pathway of innovation for food systems

**REALITY:** Non-GM advanced methods of plant breeding are already delivering the sorts of traits promised by GM crops, including resistance to diseases, flood and drought tolerance. GM crops are not only an ineffective type of innovation but they also restrict innovation due to intellectual property rights owned by a handful of multinational corporations.

# TWENTY YEARS OF FAILURE

## Why GM crops have failed to deliver on their promises

Twenty years ago, the first genetically modified (GM) crops were planted in the USA, alongside dazzling promises about this new technology. Two decades on, the promises are getting bigger and bigger, but GM crops are not delivering any of them. Not only was this technology supposed to make food and agriculture systems simpler, safer and more efficient, but GM crops are increasingly being touted as the key to 'feeding the world' and 'fighting climate change'<sup>1</sup>.

The promises may be growing, but the popularity of GM crops is not. Despite twenty years of pro-GM marketing by powerful industry lobbies, **GM technology has only been taken up by a handful of countries, for a handful of crops**. GM crops are grown on only 3% of global agricultural land<sup>2</sup>. Figures from the GM industry in fact show that only five countries account for 90% of global GM cropland, and nearly 100% of these GM crops are one of two kinds: herbicide-tolerant or pesticide-producing<sup>3</sup>. Meanwhile, whole regions of the world have resisted GM crops. European consumers do not consume GM foods<sup>4</sup>, and a single type of GM maize is cultivated in Europe<sup>5</sup>. Most of Asia is GM-free, with the GM acreage in India and China mostly accounted for by a non-food crop: cotton<sup>6</sup>. Only three countries in Africa grow any GM crops<sup>7</sup>. **Put simply, GM crops are not 'feeding the world'.**

Why have GM crops failed to be the popular success the industry claims them to be? As the promises have expanded, so too has the evidence that GM crops are ill-adapted to the challenges facing global food and agriculture systems. These promises have proved to be **myths**: some of these benefits have failed to materialize outside the lab, and others have unraveled when faced with the real-world complexities of agricultural ecosystems, and the real-world needs of farmers. In reality, **GM crops have reinforced the broken model of industrial agriculture**, with its biodiversity-reducing monocultures, its huge carbon footprint, its economic pressures on small-scale farmers, and its failure to deliver safe, healthy and nutritious food to those who need it.

It is therefore time to question the myths spun by the GM industry, and to document the flaws and limitations of this technology. Six key myths about the benefits of GM crops will be held up to twenty years of evidence:

**MYTH 1** 'GM crops can feed the world'

**MYTH 2** 'GM crops hold the key to climate resilience'

**MYTH 3** 'GM crops are safe for humans and the environment'

**MYTH 4** 'GM crops simplify crop protection'

**MYTH 5** 'GM crops are economically viable for farmers'

**MYTH 6** 'GM crops can coexist with other agricultural systems'

It is also time to question the idea that GM technology is the most promising way of harnessing scientific innovation to respond to the challenges facing food systems. The evidence shows that the real innovations for secure and sustainable food systems are not owned by corporations, and will be missed if we stay locked in the GM-industrial agriculture complex. It is therefore essential to tackle one final mega-myth:

**MYTH 7** 'Genetic engineering is the most promising pathway of innovation for food systems'

**MYTH 1.1**

“GM crops deliver higher yield”

✘ “[GM] Biotechnology enables growers to achieve consistently high yields by making crops resistant to insect attacks, or using herbicides so that weeds can be controlled more effectively.”

Syngenta<sup>8</sup>

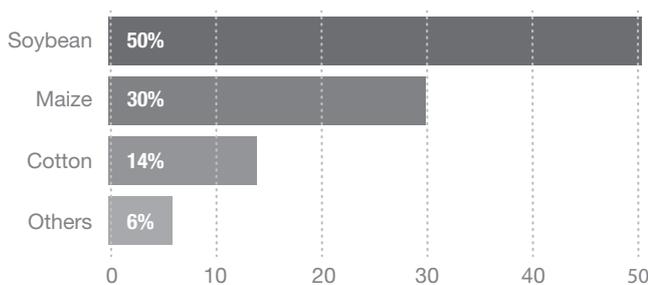
✘ “GM crops can improve yields for farmers, reduce draws on natural resources and fossil fuels and provide nutritional benefits.”

Monsanto<sup>9</sup>

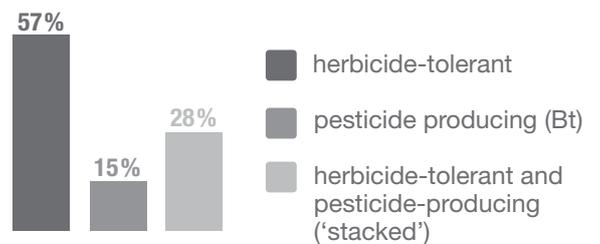
**REALITY**

ⓘ No GM crops have been designed to deliver higher yields. Where yields have been improved, the gains have tended to come not from GM technology, but from the high quality varieties created through conventional breeding to which a GM trait has then been added. Where the specific effects of GM crops have been isolated, the evidence is mixed. GM pesticide-producing crops for instance can only increase yields temporarily by reducing losses to pests in years of high infestation.

**GM CROPS AS PERCENTAGE OF TOTAL GM CROP AREA<sup>15</sup>**



**GM TRAITS AS PERCENTAGE OF TOTAL GM CROP AREA<sup>16</sup>**



## MYTH 1 “WE NEED GM CROPS TO FEED THE WORLD”

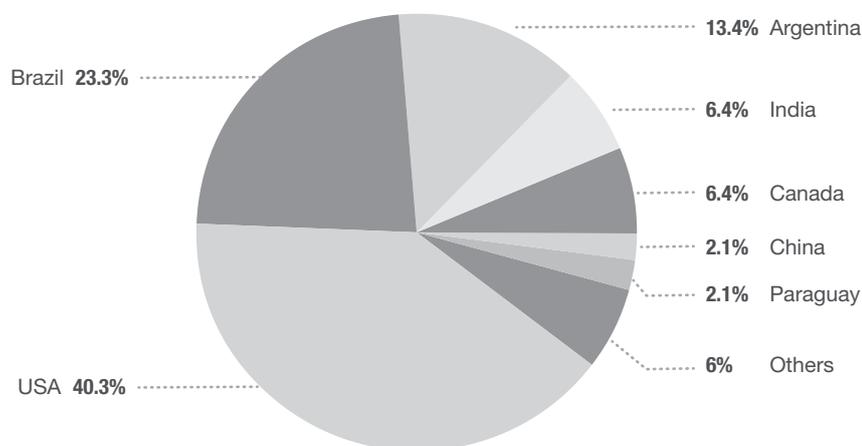
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There are no GM crops designed to increase yields. The evidence that GM crops increase yields compared to conventionally bred crops remains inconclusive<sup>10</sup>, with performance varying according to crop type, country/region and other local conditions (e.g. pest pressure in a given year, farmer training). GM crops can only increase yield by reducing losses to pests in years of high infestation, and this effect is not permanent as pesticide-producing crops lead to resistant ‘superbugs’ (see Myth 4.2). Studies examining GM crop yields have often failed to isolate the effects of GM technology from other factors, or to compare like-for-like farms.

Those farms able to take on the increased costs associated with GM crops are often the biggest and most competitive farms to start with, while the non-GM farmers figuring in comparisons may be lacking credit, training and resources<sup>11</sup>. Genetic modification has not improved the yield potential (i.e. the maximum possible yield) of crops, as this depends more on the breeding stock used to carry the genes<sup>12</sup>. Conversely, reduced yields have been attributed to the GM insertion process. For example, Monsanto’s original Roundup Ready GM soya was found to yield 10% less, when compared against the latest high-performing conventional soya crops. This was thought to be equally due to both the gene or its insertion process and differences in breeding stock<sup>13</sup>.

Meanwhile, a regional comparison shows that Western European countries have achieved higher average maize yields per hectare than the predominantly GM maize systems in the US, and Western Europe has also outperformed Canada’s GM rapeseed yields, suggesting that under similar conditions, the package of non-GM seeds and crop management practice in Western Europe is more conducive to driving yield gains than GM systems<sup>14</sup>.

### WHICH COUNTRIES GROW GM CROPS?<sup>30</sup>



MYTH 1.2

“GM crops can boost food security around the world.”



“... Many who have studied the issue agree that GMOs can help produce enough food to feed 9 billion people on our existing agricultural footprint...”

Robert Fraley,  
Monsanto executive  
vice president<sup>17</sup>

REALITY



GM crops do not respond to the challenge of food security. They are ill-adapted to the needs of the small-scale farming communities whose livelihoods are the key to food security. Instead, GM crops are grown as large-scale export commodities in a handful of developed and emerging countries, reinforcing the industrial agriculture model that has delivered large volumes of commodities to global markets - but has failed to feed the world.

There are around 500 million small-scale farms worldwide, supporting some 2 billion people livelihoods and producing about 80 % of the food consumed in Asia and sub-Saharan Africa<sup>18</sup>. These communities are also among the most vulnerable to poverty and hunger. Food security depends on the ability of these communities to access resources and markets, to secure their livelihoods, and to produce diverse and nutritious food for local communities. GM crops have not been designed to meet these needs. GM development has overwhelmingly focused on two crop commodities – soybean and maize – together accounting for 80% of global GM acreage<sup>19</sup>. By far the most common GM trait is *herbicide tolerance*, which is designed for use in large-scale monocultures (see Myth 2). GM crop production entails high and sustained input costs (see Myth 5), making GM crops even more inappropriate for the needs of small-scale farmers. Indeed, 90% of global GM acreage is in the US, Canada and three emerging countries: Brazil, Argentina and India<sup>20</sup>. However, in India, the only GM crop grown extensively by small-scale farmers is cotton – a non-food crop. In Argentina, the GM soybean boom has been driven by large-scale farmers buying up and displacing smaller farmers, as well as being environmentally damaging<sup>21</sup>.

These GM production patterns, therefore, pose a threat to the environment and resource base of small-scale farmers serving local food systems. This means that even if GM crops were to increase global yields of key staple crops – which appears unlikely (see Myth 1.1) – this would not necessarily boost *food security*. The key to tackling hunger is securing the livelihoods of food insecure communities – not producing bulk commodities for global supply chains in ways that undermine their livelihoods, food systems and natural resource base.

**MYTH 1.3**

“GM crops can be designed to work for developing countries.”



*“GMO-derived seeds will provide far better productivity, better drought tolerance, salinity tolerance, and if the safety is proven, then the African countries will be among the biggest beneficiaries.”*

Bill Gates<sup>22</sup>

**REALITY**



‘GM crops for Africa’ have fallen far short of their promises. Attempts to develop climate resilient, pest resistant and micronutrient-rich GM crops for developing countries have produced costs, complications, delays – and have often ended up refocusing on conventional crops. GM was designed for large-scale farms in the global north, and remains a technology ill-adapted to benefit the food and farming systems in developing countries.

Attempts to develop GM crops specifically for African countries have not come to fruition. One high-profile project at the Kenya Agricultural Research Institute (KARI) used Monsanto-donated technologies in a bid to develop a virus-resistant high-yielding GM sweet potato for subsistence farmers to grow. However, the potato performed badly in field trials<sup>23</sup>, and the project was criticized for channeling effort into developing a single transformed variety instead of building resilience around locally-adapted varieties<sup>24</sup>. Meanwhile, the Syngenta-funded Insect Resistant Maize for Africa (IRMA) project to distribute patent-free GM crops to farmers has also fallen well short of its goals. Intellectual property concerns arose due to licensing constraints on the underlying technology breakthroughs and the question of whether farmers would be allowed to save seed<sup>25</sup>, leading to delays, a shift to authorizing existing Monsanto GM crops, and the halting of independent GM development, with the latest project stage (2009-2013) refocusing on conventional varieties<sup>26</sup>. On the contrary, conventional breeding has yielded over 150 new drought-tolerant varieties in 13 African countries under the Drought Tolerant Maize for Africa (DTMA) project, whilst GM drought tolerant varieties are still several years away<sup>27</sup>.

Elsewhere in the world, there is much hype surrounding GM crops with in-built nutritional benefits, even though there are no such commercially-available GM crops. Nutritionally altered GM crops are at the R&D stage and these projects have a long way to go before they can even be considered for commercialisation. The most well-known of these is GM ‘Golden’ rice, engineered to produce beta-carotene which can be converted to Vitamin A in the human body, and for over a decade promoted as a solution to micronutrient deficiency in the Philippines and other Asian countries where rice is a major staple. However, despite over 20 years of development, the project is still stuck in the lab, having encountered a series of technical failures<sup>28</sup>. Moreover, local fruits and vegetables such as mango and sweet potato can, and already do, tackle micronutrient deficiency by providing a balanced and diverse diet<sup>29</sup> - not promoting a single ‘miracle crop’.

### MYTH 2.1

“GM crops can resist climate stresses”



*“The latest products are being developed to enable growers to respond to the effects of climate change such as drought and increasingly salty conditions.”*

Syngenta<sup>31</sup>



*“...we know that GMOs offer answers to some of the problems raised by global climate change - the need for crops that can use water more efficiently, for example, or that better resist bugs.”*

Robert Fraley,  
Monsanto executive  
vice president<sup>32</sup>

### REALITY



Genetic engineering has not delivered crops that are resistant to flooding or high temperatures, and lags behind conventional plant breeding in developing plant varieties that can help agriculture cope with climate change. Ultimately, climate resilience does not depend on inserting ‘drought-proof’ genes. Instead, it depends on farming practices that promote diversity and nurture the soil, as well as the multi-gene interactions developed by plants in real-life conditions of climate stress.

20 years since the first GM crop was commercially grown, farmers are still waiting for GM crops that can tolerate climate stresses such as flooding and high temperatures. While conventional and smart-bred varieties of beans, maize and rice have been released<sup>33</sup>, the high profile ‘Water Efficient Maize for Africa’ project has not yielded any successful GM varieties<sup>34</sup>. Nor have manufacturers delivered on the promise to produce GM seeds to tackle soil salinity, crop diseases or any other emerging climate-related threats. This is because genetic engineering is the wrong tool. Genetic engineering is limited to the insertion of one (or a few) genes with relatively unsophisticated control over the timing and extent of gene expression. However, traits like drought tolerance are “complex”, requiring coordination between multiple genes in the plant, which is highly difficult to achieve with genetic engineering. That’s why “smart” conventional breeding shows much more promise than genetic engineering approaches<sup>35</sup>, and is attracting more investment, in both the private and public sector. Importantly, smart breeding is already delivering drought, salinity and flood tolerance traits to several countries to help farmers cope with the impacts of climate stresses<sup>36</sup>, whilst commercial GM crops are almost entirely limited to two simple traits: herbicide tolerance and insect resistance.

Meanwhile, climate resilience depends as much, if not more, on ecological farming practices (see Myth 7.3): one of the most effective strategies to adapt agriculture to climate change is to increase biodiversity. For example, planting a range of different crops and varieties across farms increases resilience to erratic weather changes<sup>37</sup>.

### MYTH 2.2

“GM crops can be grown in eco-friendly farming systems.”



*“Biotechnology also offers significant benefits by supporting integrated crop management practices with efficient and environmentally friendly solutions to the challenges of farming.”*

Syngenta<sup>38</sup>

### REALITY



GM crops are overwhelmingly grown in the systems they are designed for: simplistic industrial monocultures that require high chemical inputs to sustain themselves, and do so at the expense of pollinators, ecosystem services and long-term soil health. Ecological farming systems are based around increasing diversity and creating synergies between plants and their ecosystems. Over-simplified farming systems of genetically identical plants run counter to these systems.

GM crops are predominantly grown in North and South America<sup>39</sup> as large-scale industrial monocultures. Industrial monocultures are over-simplified farming systems of genetically identical plants, with no refuge for wild plants or animals, where ecosystem services (besides single crop/food production) are minimized and, instead, synthetic fertilizers and pesticides are needed to maintain crop yields. For example, 85% of global GM acreage concerns herbicide tolerant crops<sup>40</sup> that are designed to survive herbicide-spraying while all other plant species are eliminated. Ultimately, monocultures are inefficient even in regard to the single goal of maximizing the mono-crop.

Degrading and eliminating other species has severe knock-on effects on the ability of ecosystems to perform the functions that support farming, eventually affecting the mono-crop as well<sup>41</sup>. This vicious cycle is especially clear in regard to pollinators. Chemical-intensive industrial monocultures with little natural habitat are major drivers of the decline in bee numbers that has sparked a pollination crisis around the world<sup>42</sup>. The marriage of GM crops and monocultures reflects the economic reality: GM seeds cost more (see Myth 5), and it is only larger farms with more collateral and greater economies of scale that can bear the costs.

**MYTH 3.1**

“GM crops are safe to eat,,



*“...GM crops are as safe as or safer than similar crops developed using more conventional breeding methods.”*

Syngenta<sup>43</sup>

**REALITY**



GM crops *are* markedly different to conventionally-bred crops, and there is no scientific consensus on the safety of GM foods. Genetic engineering inserts DNA into the plant genome, often at random, but the complex regulation of the genome remains poorly understood, making the technology prone to unintended and unpredictable effects.

GM crops are markedly different from those produced by conventional breeding, which can only take place between closely related organisms. The fundamental concern regarding GM organisms is that the inserted (or altered) genes operate outside the complex regulation of the genome, which remains poorly understood. In addition, the genetic engineering process is far from perfect. Unintended changes in plant DNA have been found in commercial GM crops, including GM Roundup Ready soya. These include multiple copies and additional fragments of inserted genes as well as rearrangements of plant DNA adjoining the inserted genes<sup>44</sup>. The inserted genes, as well as any unintended alterations to plant DNA, can inadvertently interfere with the functioning of the plant's own genes. In addition, the changes to plant chemistry, both intended and unintended, could provoke other unexpected changes in the complex chemical make-up of plants<sup>45</sup>. All this means that GM crops are prone to unexpected and unpredictable effects. However, it is very challenging to detect these effects, as there are many parameters that would need to be measured, let alone the threat they might pose to food safety.

As part of the European regulatory evaluation of GM crops, unexpected compositional differences have been identified in GM crops<sup>46</sup> but have not been investigated further. Therefore, concerns remain regarding potential health impacts such as allergenicity, particularly over the long-term. In 2015, over 300 independent researchers signed a joint statement saying there was no scientific consensus on the safety of GM crops and calling for safety to be assessed on a case-by-case basis<sup>47</sup>, as recommended by the UN's Cartagena Biosafety Protocol and the World Health Organization (WHO). Indeed, the WHO has stated: “Different GM organisms include different genes inserted in different ways. This means that individual GM foods and their safety should be assessed on a case-by-case basis and that it is not possible to make general statements on the safety of all GM foods”<sup>48</sup>.

Another way that GM crops affect human health is by increasing the release of toxic chemicals into the environment. The WHO has recently reclassified glyphosate, the herbicide used on ‘Roundup Ready’ GM crops, as a substance that is probably carcinogenic to humans<sup>49</sup>.

**MYTH 3.2**

“GM crops are safe for the environment.”



“... there has not been one documented case of biotech crops being unsafe for humans or the environment.”

Monsanto<sup>50</sup>

**REALITY**



The toxic load associated with pesticide-producing and herbicide-tolerant GM crops impacts on the environment, affecting more than just the targeted species. In addition, the genetic engineering process can affect the chemistry of plants, with unpredictable effects on their environmental interaction.

The environmental effects of both pesticide-producing and herbicide-tolerant GM crops have been well documented. Herbicide-tolerant GM crops are designed for the mass application of chemicals, and the weed resistance now rapidly emerging requires stronger formulations of herbicides, increasing the environmental impact of herbicide<sup>51</sup> (see Myth 4.1). Meanwhile, the ‘Bt toxin’ emitted by pesticide-producing GM crops has also sparked major concerns in regard to environmental safety. These include the unintended toxicity effects of these crops on organisms other than the target pest, e.g. certain butterfly species of conservation interest<sup>52</sup>, other pollinators or to species that act as ‘pest predators’<sup>53</sup> and therefore play a crucial role in natural pest control. There are also concerns that GM insect-resistant crops could have subtle but debilitating effects on the learning performance of bees<sup>54</sup>. The very design of GM pesticide-producing crops multiplies the risks: they are designed to emit pesticides in all plant cells at all times. Meanwhile, it cannot be explained why identical GM maize plants produce different levels of toxin or exactly how this variation in the Bt plant toxin concentration might affect insect resistance<sup>55</sup>.

The environmental threats posed by GM crops are not limited to toxicity. No one knows what the effects will be as these are released into the environment, given that GM crops have only been grown over large areas in the last 10-15 years. It is well known that GM crops can cause contamination of neighbouring crops (see Myth 6), but GM crops can also contaminate wild relatives. This can affect the gene pool of our wild species, possibly forever. The first case of a GM crop entering a wild population may already have occurred. In 2003, experimental GM herbicide grass escaped from a company research station and has established itself in uncultivated habitats<sup>56</sup>. It remains to be seen whether it will spread through the grass population and if it does, what implications there will be.



**300**

more than 300 independent researchers reject the ‘consensus’ on GM safety (2015)<sup>57</sup>



**26**

26 scientists wrote to US government saying companies prevent independent research on GM crops (2009)<sup>58</sup>



**90**

90 days: duration of food safety tests for GM crops<sup>59</sup>

**MYTH 3.3**

“GM crops are rigorously and independently assessed”

✘ *“GMO crops have been tested more than any crop in the history of agriculture.”*

Monsanto<sup>60</sup>

✘ *“...we advocate for supportive policies, regulation and laws that are based on the principles of sound science”*

Monsanto<sup>61</sup>

**REALITY**

**i** Independent researchers are denied access to materials for assessing the safety of GM crops and can be prohibited from publishing unfavourable findings. Researchers have also been persecuted for publishing studies raising concerns over the safety of GM crops. Meanwhile, long-term environmental and health monitoring programmes either do not exist or are highly flawed, particularly in the countries that grow the most GM crops.

One of the main problems with claims about the health and environmental safety of GM crops is that independent scientists are often denied the research materials and intellectual freedom to assess them. Independent researchers have complained about lack of access to seed material for tests on environmental effects after companies invoked Intellectual Property (IP) rules to prevent research from being carried out on their products, or to prohibit the publication of unfavourable findings<sup>62</sup>. The onerous processes requiring researchers to obtain permission from the manufacturers for any research into GM crops are themselves a major deterrent to independent research into GM crops<sup>63</sup>. Even more worryingly, independent scientists have expressed fears about persecution by the pro-GM industry. Studies showing negative impacts from GM crops have led to orchestrated and heavy-handed campaigns to discredit researchers and their findings<sup>64</sup>. Dozens of scientists wrote anonymously to the US Environmental Protection Agency (EPA) in 2009 to complain that independent research was impossible due to the power of GM companies, stating: “No truly independent research can be legally conducted on many critical questions”<sup>65</sup>.

Meanwhile, the frameworks for monitoring and regulating GM crops are currently unfit for the challenge. Despite the question marks over environmental safety (see Myth 3.2), no regional long-term environmental and health monitoring programmes exist to date in the countries with the most concentrated GM crop production. Hence, long-term data on environmental implications of GM crop production are at best deductive or simply missing and speculative<sup>66</sup>. A decade of EU funded research has provided extremely little scientific evidence addressing the environmental risks (or safety) of GM plants, failing to adequately assess the impacts of GM crops on soil health or of insect-resistant GM crops on non-target species such as butterflies<sup>67</sup>. In particular, the vulnerability of the protected peacock butterfly (*Inachis io*) in Europe to GM pesticide-producing crops is of a major concern should these crops ever be widely grown in Europe<sup>68</sup>. In addition, organisms higher up the food chain can be affected by pesticide-producing GM crops through the prey they eat, but there is no requirement to monitor these effects within safety assessments<sup>69</sup>. Normal pesticide testing occurs for two years prior to EU approval, while the duration of food safety tests for GM crops is 90 days<sup>70</sup>.

## THE GM TREADMILL : CAN YOU STAY ON TWO FEET?

### WARNING!

*Despite misleading claims from the manufacturers, the GM workout increases costs and debts, and comes with a high danger of collapse.*



Read myths 4 and 5 to find out how GM crops put farmers on a treadmill of increasing seed costs increasing pesticide use and increasing debt...

### MYTH 4.1

“GM crops simplify weed management.”

✘ “GM crops can provide farmers with the means to ... reduce pesticide applications.”

Monsanto<sup>71</sup>

✘ “Genetically modified (GM) crops do not increase the use of pesticides under good management practices.”

Syngenta<sup>72</sup>

### REALITY

**i** The initial benefits from herbicide-tolerant crops are quickly eroded as weeds become tolerant to over-used herbicides, requiring farmers to use pesticides more often, at higher dosages, and in various combinations. This gives GM manufacturers the chance to market crops resistant to several herbicides – all at a major cost to farmers and the environment.

Herbicide-tolerant ‘Roundup Ready’ GM crops were developed by Monsanto to tolerate the company’s glyphosate-based herbicides (e.g. Monsanto’s own Roundup), and are now the most common type of GM crop. In 2009, more than 90% of the soya crop planted in the US was GM herbicide-tolerant<sup>73</sup>; in 2012, 19 out of the 26 GM crops under consideration for EU approval were herbicide-tolerant crops<sup>74</sup>.

Initially, this type of crop could allow farmers to reduce the time and effort needed to control weeds. However, over the past decade these benefits have been rapidly eroded by the emergence of ‘super-weeds’<sup>75</sup>, with 14 glyphosate-resistant weed species now identified in the US<sup>76</sup>. Scientists and even GM crop manufacturers such as Dow AgroSciences are now attributing this increase to the over reliance on glyphosate<sup>77</sup>.

Weed resistance requires stronger formulations of herbicides, increasing their environmental impact<sup>78</sup>. In addition to direct toxic impacts, the use of glyphosate on most Roundup Ready crops reduces the amount of weeds in the fields, which form the base of the food chain needed to support farmland wildlife, particularly birds<sup>79</sup>, and butterflies such as the iconic Monarch butterfly in North America<sup>80</sup>.

The industry’s response has been to market new GM crops resistant to other herbicides, including maize and soy varieties engineered to tolerate the notorious 2,4-D herbicide<sup>81</sup>, an active ingredient of Agent Orange, the defoliant used during the Vietnam War.

**MYTH 4.2**

“GM crops simplify pest management”



*“Herbicide-tolerant and insect-resistant plants ... contribute to a reduction in farmer’s application of plant protection products.”*

Europabio<sup>82</sup>

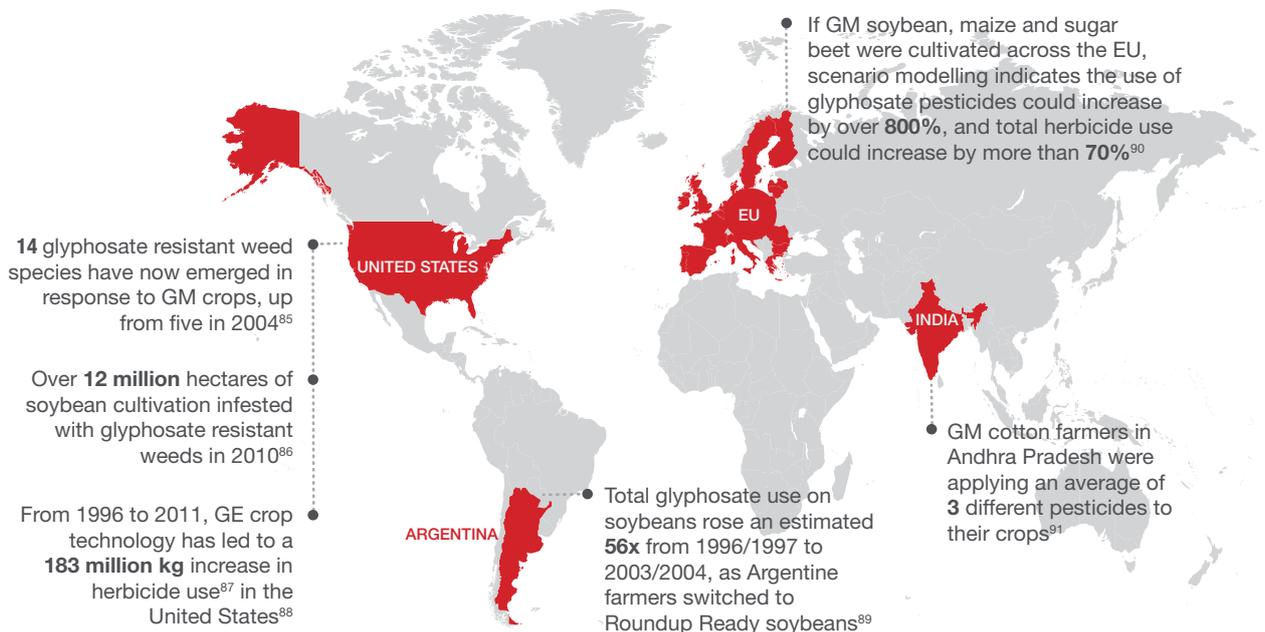
**REALITY**



GM crops that are engineered to emit insecticide increase the toxic load on the environment by producing toxins regardless of pest pressure, and by encouraging superbugs and secondary pests that are hard to control.

Alongside the weed resistance encountered by GM herbicide-tolerant crops, resistance problems have also emerged in regard to the other key type of GM crop: pesticide-producing ‘Bt’ crops. These varieties emit insecticide at all times, regardless of pest pressure, often bringing toxins to the field without any need. Just like GM herbicide-tolerant crops that encourage weed resistance, pesticide-producing crops can lead to resistant ‘superbugs’<sup>83</sup>, as well as allowing other pests to fill the void of the eliminated species<sup>84</sup>. Farmers end up spraying toxic insecticides to protect against these secondary pests, incurring additional costs. Furthermore, there are concerns over the unintended toxicity effects of these pesticide-producing GM crops on organisms other than the target pest, and the knock-on effects this might have on ecosystems, and particularly on the predator species which are crucial to natural pest management strategies (see Myth 3.2). Together, these factors severely undermine the promise to simplify and reduce the costs of pest management.

**CROP PROTECTION FAILURES**



**MYTH 5.1**

“GM seeds are affordable for farmers.”



“The seed market for these crops is competitive today in terms of company shares, number of choices, and prices paid by farmers.”

Monsanto<sup>92</sup>

**REALITY**

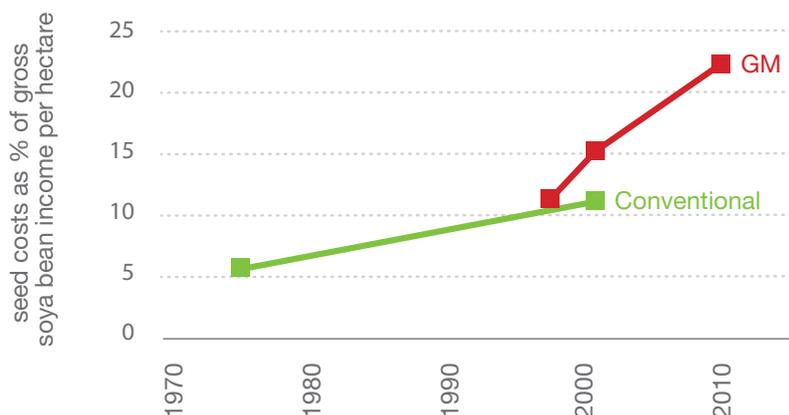


GM seed prices have soared since coming onto the market twenty years ago, and are considerably more expensive than conventional seeds. Given that GM seeds are protected by patents, it is not possible to save and replant seeds – meaning high and persistent costs for farmers.

All seeds arising from advanced breeding techniques are likely to cost more. However, the ‘technology fees’ built into seed prices have risen higher for GM than for non-GM seeds. Since 2000, as GM soybean started to dominate the US market, soybean seed prices have soared by over 200%, after having risen only 63% over the previous 25 years<sup>93</sup>. Maize prices have evolved similarly<sup>94</sup>. By 2012, the GM maize seed price averaged \$263/unit, compared to \$167 for conventional seeds<sup>95</sup>. GM seeds with ‘stacked traits’, e.g. with inbuilt tolerance of multiple herbicides, are even more expensive.

Crucially, these are *annual* outlays for farmers: agrochemical companies do not allow farmers to save seeds for the next growing season as this is considered to be an infringement of the patents taken out on GM crops. Moreover, farmers planting GM pesticide-producing crops pay for a crop that emits insecticide at all times – regardless of pest pressure (see Myth 4.2). These high and persistent costs, coupled with the dubious benefits, have made GM a viable technology only for farmers operating at large scale with sufficient assets, collateral and willingness to take on debt.

**COST OF SOYBEAN SEED<sup>96</sup>**



**MYTH 5.2**

“GM crops allow farmers to save on other input costs.”



“...the introduction of insect-resistant Bt cotton has reduced the number of applications of insecticides and this reduced the costs for the farmers.”

Bayer<sup>99</sup>

**REALITY**



GM crops may initially reduce labor costs through simplified pest control. However, the emergence of herbicide-resistant weeds, super-pests and secondary pests can rapidly erode these initial savings. This, combined with the much higher cost of seeds, means that in the medium and longer-term, the total input costs associated with GM crops are likely to remain high.

Even if farmers end up paying more for GM crops, can they recoup their money through cheaper production costs? In principle, Roundup Ready and other herbicide-resistant crops reduce labor costs by allowing singular pesticide treatments across large areas, while pesticide-producing crops can reduce the need to spray insecticides. This should bring down expenses on pesticides as well as labor costs. However, as seen in Myth 4.1, the emergence of super-weeds can rapidly erode these benefits, requiring farmers to ramp up pesticide applications and upgrade to more expensive ‘stacked trait’ GM crops. The emergence of super-pests and secondary pests, as explained in Myth 4.2, also requires major pesticide outlays.

In 2004, after several years of commercialization, GM cotton farmers in China were spending \$101/ hectare on pesticides<sup>100</sup>, almost as much as conventional farmers, and were spraying pesticide nearly three times more often than in 1999<sup>101</sup> – suggesting that labor savings can also be swiftly eroded. When labour costs do come down, this may ultimately be a false economy. In the industrial agriculture and GM cropping model, knowledge comes from the top-down and is built into the seed, with little value placed in the knowledge residing with farmers and farmworkers. This means that as labour costs are pared down, farmers’ knowledge of local agro-ecosystems may be lost – knowledge that is the key to sustaining both the environment and crop yields in the longer-term, especially when seeds don’t perform as expected.

**AVERAGE MAIZE SEED PRICE / UNIT (2012)<sup>97</sup>**

GM maize  \$ 263

Conventional  \$ 167

MYTH 5.3

“GM crops improve the livelihoods of small-scale farmers in developing countries.”



*“We use the technology to develop better seeds and nurture the partnerships to develop new agronomic practices that can have a huge impact on the lives of farmers.”*

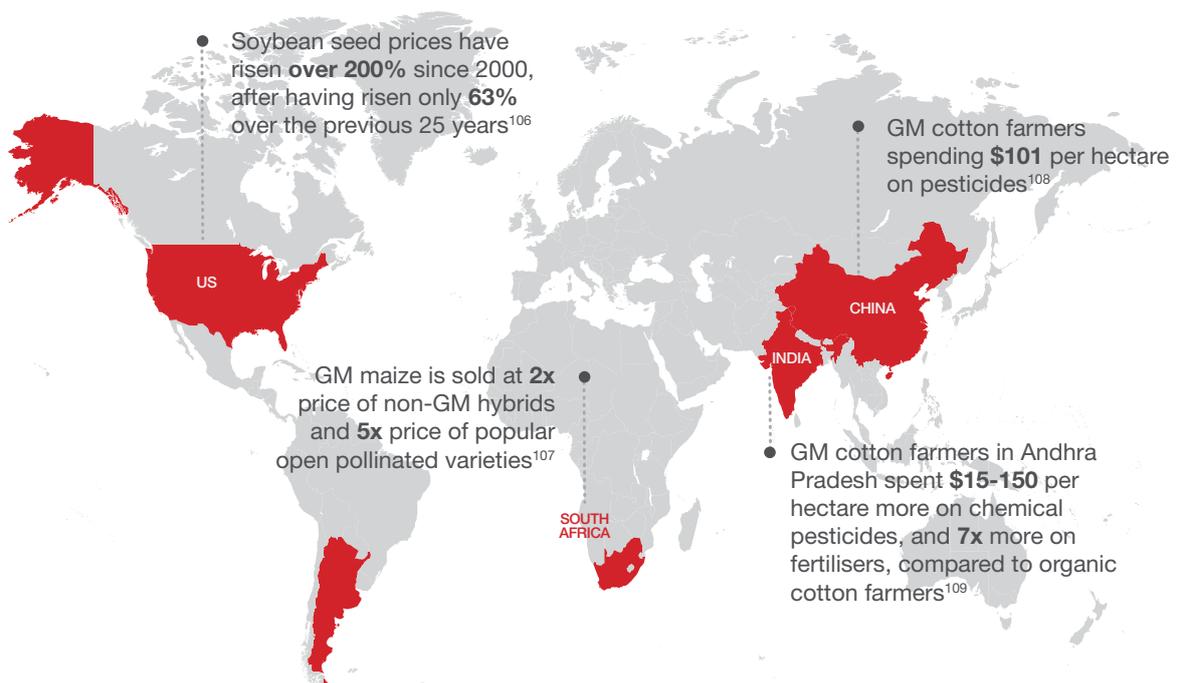
Monsanto<sup>102</sup>

REALITY



GM crops are highly inappropriate for the challenge of securing small-scale farmers’ livelihoods, and have barely featured in smallholder-based food systems. Where small-scale farmers have grown GM crops, yields have been variable and dependent on optimal growing conditions, while seed and input costs have remained high, often requiring debt to be incurred on unfavorable terms. As such, GM crops have failed to stabilize, secure and improve the livelihoods of small-scale farmers.

THE HIGH AND PERSISTENT COSTS OF GM CROPS



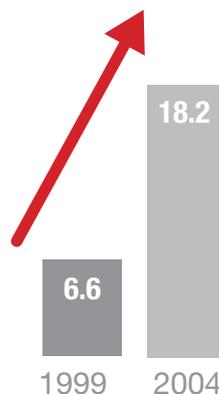
## MYTH 5 “GM CROPS ARE ECONOMICALLY VIABLE FOR FARMERS”

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To date there has been little uptake of GM crops by small-scale farmers in developing countries (see Myth 1.2). Bt cotton in India is the exception, and is often used by GM manufacturers to highlight the benefits for small-scale farmers. In reality, the impacts have been marginal in yield terms, and often negative when considered in terms of financial security, livelihoods and wellbeing. A Greenpeace comparison of GM (Bt) cotton and organic cotton farmers in India showed that while GM farmers experienced slightly higher yields under favourable climate conditions, these yields collapsed under climate stress. Despite not having access to the latest high-performing non-GM seeds, organic farmers had more stable yields, lower input costs, and higher returns – achieving more secure livelihoods<sup>103</sup>. A similar picture has emerged for small-scale farmers cultivating Bt Maize in South Africa. Bt maize seeds are five times as expensive as popular open-pollinated varieties, and require optimal growing conditions (e.g. well-irrigated land) in order to perform well; this makes the technology unviable for many small-scale farmers, paying off only in years of high pest pressure, and exposing their livelihoods to excessive risk<sup>104</sup>.

Debt is also likely to be incurred in order for small-scale farmers to cover the costs of growing GM crops. When other input costs fail to drop (see Myth 5.2), and yields fail to improve by any significant margin (see Myth 1.1), farmers encounter severe difficulties in servicing their debts and staying afloat. Greenpeace’s Indian case study showed that Bt cotton farmers ended up getting heavily indebted to private money lenders after failing to access microcredit on more favourable terms<sup>105</sup>. But even on the best possible terms, a technology that entails high and sustained input costs, and requires farmers to incur heavy debt, will always be more suited to the factory farms and monocultures of industrial agriculture. GM crops are therefore far from optimal for the small economic units that dominate the global farming landscape.

### NUMBER OF PESTICIDE TREATMENTS BY GM COTTON FARMERS PER SEASON (CHINA)<sup>98</sup>



MYTH 6.1

“Contamination of other agricultural systems by GM crops can be avoided.”



“... there is no credible evidence that existing GM crops are or could be any more difficult to manage than conventionally bred crops.”

Syngenta<sup>110</sup>

REALITY



Nearly 400 officially recorded incidents of GM contamination have occurred around the world, with companies and governments failing to keep the GM and non-GM food chains separate. Far more incidents are likely to have happened, but have not been discovered or denounced.

By the end of 2013, nearly 400 incidents of GM contamination of crops had been recorded around the world<sup>111</sup>. Multiple pathways to contamination have been observed, including human error at the seeding, harvesting, labelling, and storage stages, as well as ineffective segregation systems. When contamination does occur, farmers often pay the price in terms of lower selling prices (e.g. losing the organic premium), the costs incurred in collecting contaminated produce and placing it back on the market, and reputational damage, resulting ultimately in lost revenues<sup>112</sup>. But companies can suffer financially from GM contamination too. In 2006-2007, contamination from Bayer’s experimental GM rice cost US farmers an estimated \$27.4 M in lost revenue, and up to \$1.29 bn in total losses across the sector, after several countries banned imports of US rice<sup>113</sup>.

National oversight systems have been found to be severely lacking. In Spain, thousands of hectares of Bt maize are grown without the government taking measures to evaluate, let alone prevent, the contamination of conventional or organic maize fields, with measures for separation, segregation, and control by the Spanish administration largely absent, making it increasingly difficult for farms to stay GM-free<sup>114</sup>.



396

incidents of recorded GM contamination (1994-2013)<sup>115</sup>

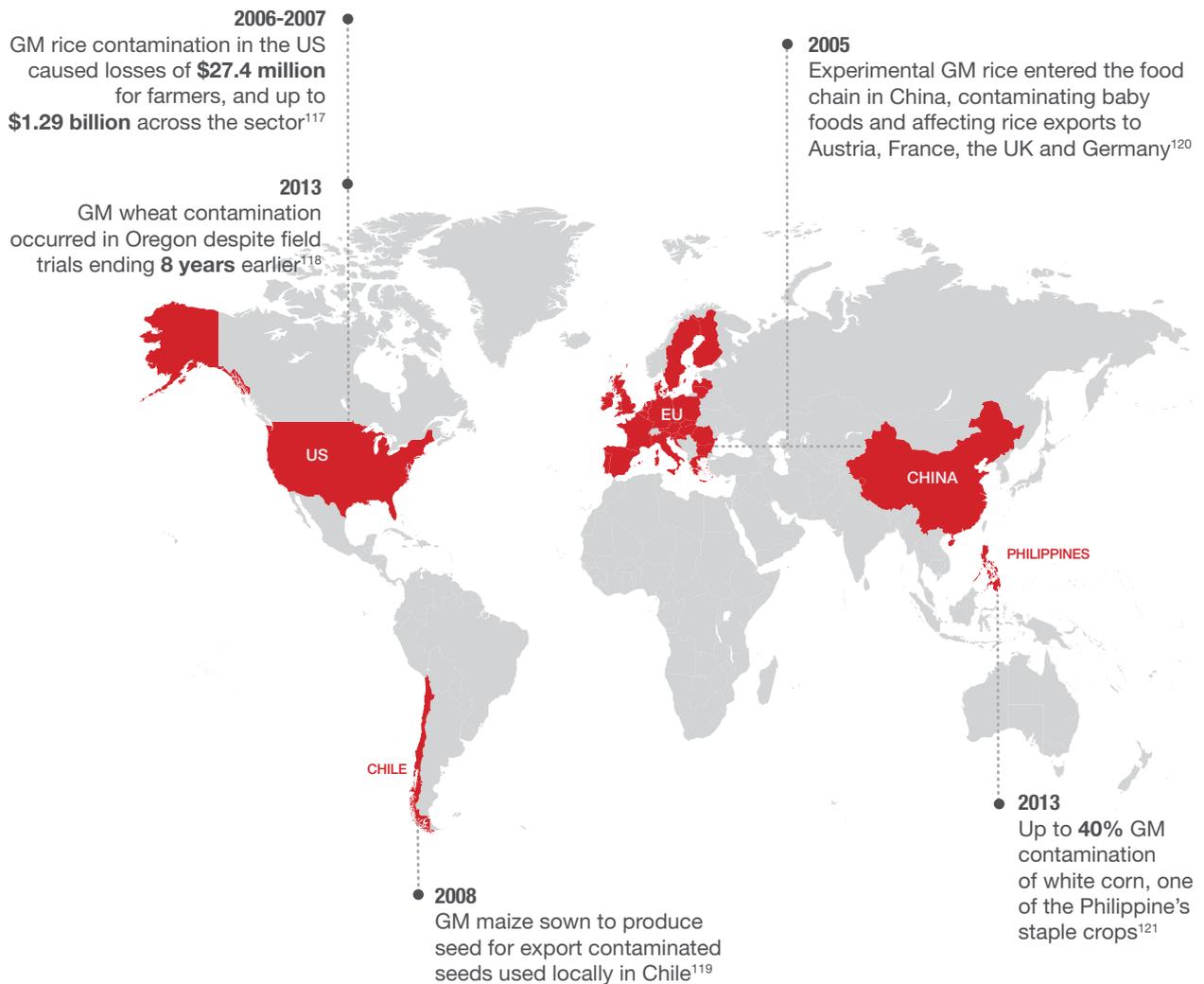


63

different countries affected by GM contamination<sup>116</sup>

## MYTH 6 “GM CROPS CAN COEXIST WITH OTHER AGRICULTURAL SYSTEMS”

### MAP OF GM CONTAMINATION



**MYTH 6.2**

“GM crops will stay out of the food chain until authorized”



“Importantly, as all parties work to verify these findings, the glyphosate-tolerance gene used in Roundup Ready wheat has a long history of safe use.”

Monsanto on experimental wheat contamination<sup>122</sup>

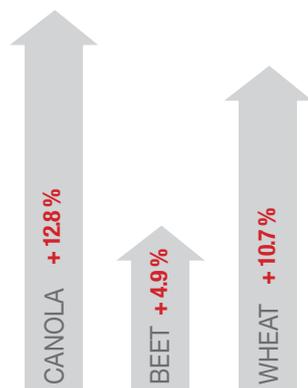
**REALITY**



Experimental varieties of wheat, rice, maize and other GM crops have escaped from field trials and entered the food chain – with GM pharma and biofuel crops now threatening to do the same.

In several cases, harvests have been contaminated by GM crops that are supposed to be confined to the lab, including self-pollinating crops with limited pollen spread. Contamination has arisen from unauthorised or experimental varieties of GM papaya in Thailand and Taiwan, GM maize in the EU, GM linseed in Canada, GM wheat in the US, and GM rice in the US and China<sup>123</sup>. In many cases, the cause is simply unknown: Bayer said its rice contamination in the US (see Myth 6.1) was an “Act of God”<sup>124</sup>. Worryingly, these cases are the ones that have been detected: the information required to test for GM contamination from field trials is kept confidential. Meanwhile, biotech companies are also in the process of engineering dedicated crops for biofuels and the pharmaceutical industry. If these experimental crops contaminate the food supply, then humans would unknowingly be consuming proteins not normally present in the human diet.

**ADDITIONAL COSTS TO GERMAN FOOD INDUSTRY IF GM ENTERS THE CHAIN<sup>132</sup>**



**ADDITIONAL EU SEED PRODUCTION COSTS IF GM CANOLA WAS AUTHORIZED<sup>133</sup>**



**MYTH 6.3**

“The costs of staying GM-free are manageable.”



*“All of the agricultural systems can and do work effectively side by side, meeting the varied needs of different consumers and the demands of a growing population.”*

Monsanto<sup>125</sup>

**REALITY**



Staying GM-free imposes huge costs for farmers, putting particular pressure on the organic sector, and sometimes leaving farmers no choice but to adopt the GM crops surrounding and contaminating their fields. Major additional costs are also faced by seed manufacturers, and food processors in order to maintain GM-free supply chains.

In zones where GM crops are grown, non-GM farmers are often forced to undergo costly and disruptive steps such as planting early or late to avoid contamination at drying plants. Greenpeace found that organic maize farmers in Spain sometimes ended up adopting GM maize because the costs of avoiding contamination were too high, creating an illusion of ‘coexistence’ because there was nothing left for GM to coexist with<sup>126</sup>.

In Aragon, where GM maize is prevalent, the organic farming area dropped 75% between 2004-2007, on the back of contamination cases and the threats to social cohesion (e.g. within villages) in attempting to resolve them<sup>127</sup>.

Meanwhile, a Canadian study on the projected impacts of introducing GM wheat determined that controlling ‘volunteer’ GM crops would become the largest single on-farm expense<sup>128</sup>. The additional costs cascade through the agri-food sector. Upstream, seed manufacturers face costly procedures to avoid the type of contamination that has occurred in Chile<sup>129</sup>.

In the EU, estimates suggest that canola seed production costs could increase by 10% if GM canola was authorized for cultivation<sup>130</sup>. Downstream, the profusion of GM ingredients in global supply chains imposes costs on food processors wishing to respect the wishes of European consumers, who rightly demand to know that their food is GM-free. A 2009 study estimated that the GM segregation costs faced by German industry could lead to up to 13 % higher price for GM-free canola oil, 8% for starch from GM-free wheat and 5% for sugar from GM-free beets<sup>131</sup>.

**MYTH 7** “GENETIC ENGINEERING IS THE MOST PROMISING PATHWAY OF INNOVATION FOR FOOD SYSTEMS”

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**MYTH 7.1**

“Genetic engineering boosts innovation and competitiveness”

✘ *Patenting GM crops “promotes investment in scientific research and the development of new technologies.”*

Syngenta<sup>134</sup>

**REALITY**

**i** GM crops are not only an ineffective type of innovation, they are bad for innovation itself. They turn plant development processes into private property, restricting access and sharing of genetic resources, and introducing intellectual property concerns that work against developing countries. GM crops have also spawned corporate seed monopolies, resulting in less choice for farmers – and more power for the industry.

As myths 1-6 show, GM technology has failed on its own terms, e.g. to reduce pesticide intensity in agriculture, or to yield drought-resistant crops. **But GM crops are not just an ineffective type of innovation – they are bad for innovation itself.** GM crops are designed in a way that hoards knowledge and power, rather than putting it in the hands of farmers. Agricultural companies are able

**MONSANTO IN FIGURES**



**112**

Monsanto had filed 112 lawsuits against farmers for alleged violations of intellectual property rights as of 2007.<sup>143</sup>



**21<sup>M</sup>**  
**\$**

Monsanto collected over \$21 M in fines from US farmers (1996-2007).<sup>144</sup>



**160<sup>M</sup>**  
**\$**

Monsanto received up to \$160 M in out-of-court settlements (1996 to 2007).<sup>145</sup>

## MYTH 7 “GENETIC ENGINEERING IS THE MOST PROMISING PATHWAY OF INNOVATION FOR FOOD SYSTEMS”

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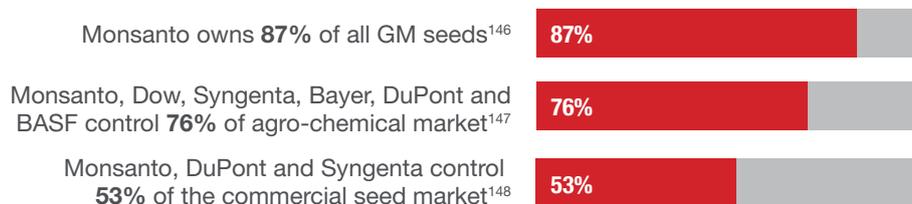
to patent seed technologies in many countries because it is considered intellectual property (IP), and therefore comes with rights and protections.

GM seed manufacturers claim that patents are needed in order to give them the incentive to innovate<sup>135</sup>. However, the real effect of GM seed patents is to concentrate knowledge and block innovation. Turning plant development processes into private property not only allows companies to draw greater profits from their seeds (see Myth 5.1). It also puts whole swathes of genetic material off-limits for others.

In 2008, the UN Global Agriculture Assessment, conducted over a 4-year period by 400 scientists and signed by 58 governments, warned that *“The use of patents for transgenes ...may drive up costs, restrict experimentation by the individual farmer or public researcher while also potentially undermining local practices that enhance food security and economic sustainability...”*<sup>136</sup>.

The ability to own and patent genetic material has also concentrated immense wealth and power in the hands of a few agribusiness firms. Six companies - Monsanto, Dow, Syngenta, Bayer, Dupont and BASF – own almost all GM crops commercialized globally, and control 76% of the agro-chemical market<sup>137</sup>. This means that the same firms making GM seeds profit from the extra pesticides necessary for GM farming. Indeed, the leading GM manufacturers are primarily agrochemical companies that have moved into seed production as lucrative patented seed opportunities have emerged. The logic is contagious, with seed companies now filing patents on traditionally-bred plants and building up new monopolies in conventional seeds<sup>138</sup>. **GM-style innovation means less choice for farmers:** the US National Family Farmers Coalition reports several seed companies being first bought by Monsanto and then withdrawing their conventional varieties from the market<sup>139</sup>. Meanwhile, in Colombia, dominance of the market by Monsanto has meant cotton growers have struggled to find viable alternative seeds<sup>140</sup>. Overall, 53% of the commercial seed market is now controlled by three firms: Monsanto, Du Pont and Syngenta<sup>141</sup>. This market stranglehold is the context in which farmers are making so-called ‘independent decisions’ to grow GM crops. It is bad for farmers, and it is bad for innovation itself, with progress in plant breeding hampered and slowed down when competition, research and development are impacted by seed monopolies<sup>142</sup>.

### CORPORATE CONCENTRATION IN AGRICULTURAL INPUTS



## MYTH 7 “GENETIC ENGINEERING IS THE MOST PROMISING PATHWAY OF INNOVATION FOR FOOD SYSTEMS”

### MYTH 7.2

“Genetic engineering is the most promising form of crop innovation.”



*Genetic engineering “allows plant breeders to do faster what they have been doing for years – generate superior plant varieties – although it expands the possibilities beyond the limits imposed by conventional plant breeding”*

EuropaBio<sup>149</sup>

### REALITY



Smart breeding or marker assisted selection (MAS) uses non-GM biotechnology to deliver a wide range of traits for a wide range of crops. MAS has allowed breeders, often from public institutions, to provide farmers with crops resistant to droughts, floods and fungi as well as tolerant to salty soils. Such biotechnology is better-suited than genetic engineering to deliver region-specific breeding approaches and to harness the knowledge of farmers through participatory breeding. These advances show that genetic engineering is not the only pathway to hi-tech innovation in seed breeding – and is not the most promising.

As a result of the hype surrounding GM crops, other innovations in seed breeding have been overshadowed – despite delivering quicker, safer and more relevant solutions to the challenges facing food systems. For example, marker assisted selection (MAS) uses conventional breeding so that the desired genes that are bred into the plant are under the control of the genome. Unlike genetic engineering, MAS does not involve the transformation of isolated (usually foreign) genetic material into the genomes of plants, drawing instead on techniques that have a long history of safe use in conventional breeding.

MAS is already yielding a wide range of traits in a wide range of crops. For example, fungal resistance has been bred into varieties of barley, bean, chilli, lettuce, pearl millet, rice, soybean, tomato and wheat<sup>150</sup>. New varieties delivered through MAS also include crops tolerant to droughts, floods and soils with high salinity<sup>151</sup>. Sophisticated techniques used in MAS allow genetic resources from wild relatives and landraces to be exploited for the improvement of plant varieties in ways that enrich the cultivated gene pool<sup>152</sup>. While MAS seeds are sometimes patented, this form of seed-breeding has more scope to harness the knowledge of farmers in open and participatory ways<sup>153</sup>, as well as offering region-specific breeding approaches. And MAS appears less likely to be captured by a handful of developers: as many as 136 *publicly bred* MAS varieties were identified in Greenpeace’s 2014 ‘Smart Breeding’ report<sup>154</sup>. MAS is no panacea, but its achievements show that **GM is not the only pathway to hi-tech innovation in seed breeding – and is not the most promising.**

**MYTH 7** “GENETIC ENGINEERING IS THE MOST PROMISING PATHWAY OF INNOVATION FOR FOOD SYSTEMS”

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**MYTH 7.3**

“Ecological farming cannot answer the challenges we face, and cannot feed the world.”

✘ *“Organic agriculture by itself is not resource-efficient enough to meet the food demands of today and the future. Truly sustainable solutions to farming should integrate all available modern crop protection technologies and plant varieties.”*

Syngenta<sup>155</sup>

✘ *“When you go from six to nine billion over the next 30/40 years there is no new land. Can you do it without biotech? I don’t think so. (...)The thing that often frustrates me in the debate is that there is never an alternative... The other side of this is still pretty empty.”*

Hugh Grant,  
Monsanto CEO<sup>156</sup>

**REALITY**

**i** Many of the key innovations in food systems are not owned by corporations, and nor are they confined to Western labs. Ecological farming techniques are already delivering major successes in fighting pests, sustaining yields, preserving ecosystems, as well as securing and improving the livelihoods of small-scale farmers. These successes have been achieved at scale, in the places where food security is most threatened. They cannot alone defeat food insecurity, given the deep social and political drivers of poverty and hunger. But unlike the industrial agriculture model driven forward by GM crops, ecological farming techniques provide farmers with the tools to durably improve their yields, their environments and their livelihoods.

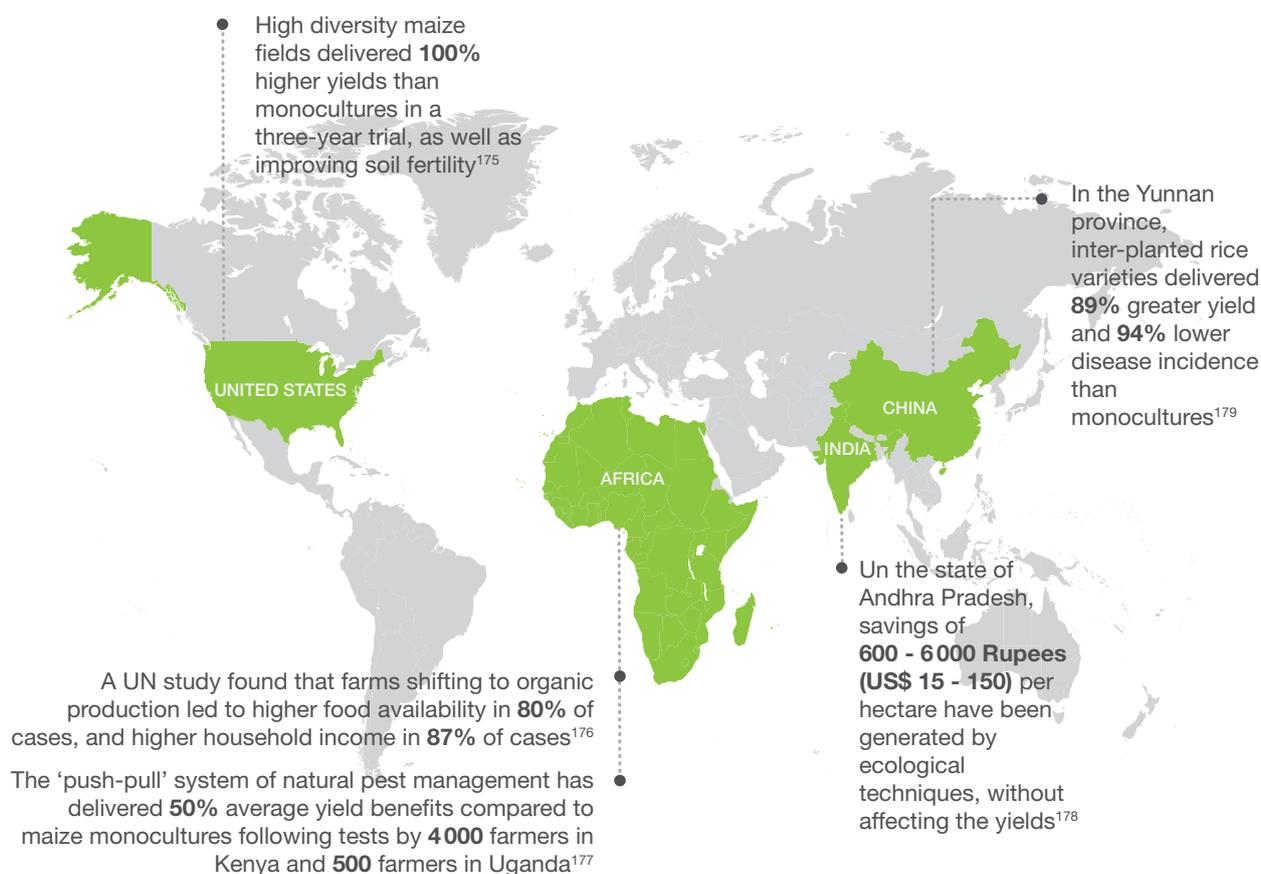
While GM traits such as herbicide tolerance try to isolate plants from their environment so they can thrive in specific conditions, ecological farming techniques nurture ecosystems as a whole, harnessing the natural diversity of plants and the synergies between species in order to achieve resilience to a range of conditions. Scientists have shown that diversity provides a natural insurance policy against major **ecosystem changes**<sup>157</sup>. Fields with the highest crop diversity delivered maize yields over 100% higher than continuous maize monocultures<sup>158</sup>. In Italy, genetically-diverse wheat fields were able to avoid yield losses under lower rainfall scenarios<sup>159</sup>. Diversity has

## MYTH 7 “GENETIC ENGINEERING IS THE MOST PROMISING PATHWAY OF INNOVATION FOR FOOD SYSTEMS”

also proven to be key to sustaining yields in the face of **pests and disease pressures**. In the Chinese province of Yunnan, rice varieties susceptible to rice blast delivered a 89% greater yield and 94% lower disease incidence when inter-planted with resistant varieties than when grown in a monoculture<sup>160</sup>. Ecological farming innovations can also deliver major gains in **soil fertility**. An analysis of 77 studies showed that legumes used as green manures can fix enough nitrogen to replace the entire amount of synthetic nitrogen fertilizer currently in use, without losses in food production<sup>161</sup>. These advantages endure over time: in a 20+ year-long study on European farms, soils that were fertilised organically showed better soil stability, enhanced soil fertility and higher biodiversity, including activity of microbes and earthworms, than soils fertilised synthetically<sup>162</sup>.

Proponents of GM and industrial agriculture sometimes accept the environmentalists insist that ecologically-produced food is a luxury fad for rich consumers – and cannot possibly feed the world. However, ecological farming techniques offer durable solutions to the pest, disease and climate stresses that threaten harvests, and are therefore highly productive, as well as environmentally-friendly. Farming with ecological practices is an effective way to increase yields and reduce the ‘yield gap’ between organic farming and conventional farming<sup>163</sup>. Not only does

### ECOLOGICAL FARMING SUCCESSES AROUND THE WORLD



## MYTH 7 “GENETIC ENGINEERING IS THE MOST PROMISING PATHWAY OF INNOVATION FOR FOOD SYSTEMS”

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ecological farming sustain yields, but it also improves incomes over the longer term: a decade long study in Wisconsin (US) showed that farming with high diversity and with no pesticides or chemical fertilisers is more profitable than farming with monocultures and chemicals<sup>164</sup>. Across Europe, for example, a region-wide analysis indicates that profits on organic farms are on average comparable to those on conventional farms<sup>165</sup>. Labour costs may be higher in ecological farming systems, but these costs are often offset by savings on input costs<sup>166</sup>.

Crucially, the gains are particularly strong in the places where food security is most threatened. A UN analysis of 15 organic farming examples in Africa have shown increases in per-hectare productivity for food crops, increased farmer incomes, environmental benefits and strengthened communities<sup>167</sup>. In the Indian states of Andhra Pradesh and Telengana, whole villages have rejected chemical agriculture and employed ecological techniques in ways that have generated between 600 and 6 000 Indian Rupees (US\$ 15 - 150) saving per hectare - without affecting the yields<sup>168</sup>. Nor are these benefits limited to small samples. The ‘push-pull’ system of natural pest management through sophisticated intercropping has been spread to 4 000 farmers in Kenya and 500 farmers in Uganda, delivering 50% average yield benefits compared to maize monocultures<sup>169</sup>. Meanwhile, the ecological farming revolution in Andhra Pradesh and Telengana now covers 15% of the arable land in those states, and has reached more than 2 million smallholders<sup>170</sup>.

Over two decades, huge amounts of public and private funding have been ploughed into GM crops: tens of millions of dollars have been spent on developing the failed GM ‘Golden Rice’ alone<sup>171</sup>. Meanwhile, management-based ecological farming approaches do not offer major profit incentives for corporations, and have therefore received considerably less investment<sup>172</sup>. It is remarkable therefore, that ecological farming has already been so successful in delivering ecological resilience, strong and sustainable yields, decent income and *secure farming livelihoods*. Unlike the *capital-intensive* model of industrial agriculture and GM cropping, ecological farming is *knowledge-intensive*<sup>173</sup>, and therefore viable for farmers all over the world – not just the biggest farms. The potential for further ecological farming breakthroughs is huge, and given the diversity of ecological farming solutions, a broad range of incentives and support frameworks may be needed<sup>174</sup>. Much of the innovation will come from farmers themselves, provided that their livelihoods are secured, their environment is preserved, and their freedom to innovate is protected. After twenty years of failures, it is clear that GM crops are incompatible with the type of innovation, the type of transition and the type of food systems we need.

**A technology that encourages monocultures, escalates pesticide use, fuels corporate monopolies and increases the economic pressure on farmers is clearly part of the agro-industrial past - not the ecological future.**

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# GREENPEACE

Greenpeace is an independent global campaigning organisation that acts to change attitudes and behaviour, to protect and conserve the environment and to promote peace.