Agro-ecological impacts of genetically modified soy production in Argentina and Brazil

An analysis of twelve claims about GM soy

GM Soy Debate

Contents

Preface

This is the first of a series of publications for the GM Soy Debate reviewing the evidence on sustainability issues related to the cultivation of genetically modified soy (GM soy). The GM Soy Debate was launched to support a constructive public debate about the possible impacts of GM soy on sustainable agriculture, and to inform public policy making and political decisions. Our aim is to build an agreed knowledge base through research and stakeholder consultations.

GM soy has wide-ranging and complex implications. This publication focuses on the production of soy in Latin America, in particular Argentina and Brazil, and on the environmental aspects related to soy production; social and economic considerations are not addressed. It draws on the findings of a scientific study by Plant Research International B.V. at Wageningen University, the Netherlands. The study concentrates on the impacts of RoundupReady soy (RR soy), the only variety of GM soy currently in commercial use. The information it contains is derived from peer-reviewed scientific literature. While this ensures a certain quality control, the sheer availability of scientific literature on some of the topics in this publication and the differences in methodology and presentation of results imposed some constraints on the scope of the study.

Introduction

The agricultural system

Agriculture has been transformed into a high-tech system for satisfying the world's growing demand for food, feed, fiber and fuel, boosted by the export opportunities opened up by the global market. Nevertheless, a complex arrangement of agricultural policies and trade rules has evolved to defend the many interests at stake. These include not only food security, food safety, and protection for domestic farming and agribusiness sectors, but also consumers' interests, especially the price of food in the supermarket.

This agricultural system is geared primarily toward increasing efficiency, measured as production costs per unit of product – often translated into maximizing output per hectare. Typical features include large farm size, specific cropping patterns and tillage practices, use of machinery and agro-chemicals, and plant breeding. Plant breeding has always been an important element in raising the security, volume and quality of crop yields in all types of agricultural systems, including conventional and organic. Plant breeding is a highly advanced technology making use of knowledge about the physiological, biological and genetic properties of the plant. Besides better yields, crops are bred for characteristics that are useful after harvesting, for example to prolong the conservation life of agricultural products or facilitate their

processing into end products. However, as demand for feedstocks soars, and awareness of the limits of natural resources and human capital grows, the sustainability of this agricultural system is increasingly questioned.

Soy

Soy is a clear example of these changes in agriculture. Along with wheat and corn, it is one of the most important staple crops for the industrialized food system. It is the basis for a range of products, from protein-rich soy meal for animal feed to vegetable oil for human consumption. Components of the soy bean are also feedstocks for bio-based products and biodiesel.

Soy production has increased significantly in the last two decades, particularly in Latin America, which now accounts for more than half of global soybean production. The additional production in this region is largely for the export market; China and Europe are the main buyers. To meet global demand, many Latin American farms have become large and highly mechanized soybean production facilities.

In the 1990s Monsanto Company introduced a genetically modified soy variety called RoundupReady soy (RR soy). RR soy is resistant to the herbicide glyphosate, which is toxic to most plants and weeds, and is also produced by Monsanto. The idea behind RR soy is that it makes it easy to control weeds in the fields, leaving the RR soy unaffected after application of the herbicide. Today, RR soy is the only commercially authorized and widely used GM soy in Latin America. In Argentina GM soy now makes up about 95% of all the soy cultivated; in Brazil the proportion is 66%. Other GM soy varieties that may be used commercially in the near future copy the RR soy mechanism of conferring resistance to a herbicide.

More than a decade ago, the first commercial plantings of GM soy sparked a debate on the possible effects of using these crops. Concerns are not limited to the possible environmental and health impacts of these crops, but also include the possible socioeconomic aspects and ethical considerations. In Latin America, the debate concentrates on the expansion of soy cultivation into high biodiversity regions.

Several companies in the soy supply chain are now drawing up criteria for responsible soy production. One of these initiatives is the Round Table on Responsible Soy (RTRS), an international multi-stakeholder platform. The RTRS does not distinguish between conventional or GM soy, stating that "each of the practiced production models has room for model-specific improvements". But while the huge acreage of GM soy justifies a deeper debate on the position of GM soy in a sustainable agriculture system, the public debate has lacked constructive deliberation on the possible benefits and problems of GM soy.

The GM Soy Debate

The GM Soy Debate was established to promote a constructive public debate about the possible impacts of GM soy, and to inform public policy making and political decisions. Its website serves as an international platform for discussion.

This publication looks at twelve claims about the environmental impacts of GM soy often made in public discussions on GM soy. They represent the views and opinions of the stakeholders in the production chain. To build an agreed knowledge base, we have to understand the arguments that underpin these claims in more detail. We asked the following questions: How widely applicable is the claim? What supporting evidence is there? How specific is the claim for GM soy? Which factors affect the environmental impacts? Do we need any more information to understand these impacts?

Many of the claims apply to the agricultural system or the cultivation of soy in general. The introduction of GM soy can mitigate some environmental impacts, but appears not to be the essential or decisive factor. The observed effects may result from the accompanying changes in application of herbicides in GM and conventional farming systems, and the resulting environmental impacts. This deserves further investigation.

For each claim we give a brief introduction to the topic, followed by a summary of the available information. Where possible, we provide an answer to the questions raised by the claims.

Twelve claims about the environmental impacts of GM soy

- GM soy yield is different from conventional soy
- GM soy changes the use of crop protection agents in soy and the environmental impacts from these agents
- GM soy stimulates the development of herbicide resistance among weeds
- GM soy aggravates problems in the control of volunteer soybean in subsequent crops
- GM soy facilitates zero tillage
- GM soy facilitates monocropping
- GM soy has an impact on biodiversity in and around agricultural fields
- GM soy is a threat to nearby farms that want to cultivate GM free soybean
- GM traits in soy can spread and persist outside agricultural fields
- GM soy facilitates the expansion of soy production into natural areas
- GM soy affects the genetic diversity of soy varieties in Latin America
- GM soy changes the scale of soy farming in Latin America

1 GM soy yield is different from that of conventional soy

Yield is the amount of agricultural product that is produced on a given acreage. Yield is also an indicator of the amount of food produced, and thus the availability of food and the pressure on food security and food prices.

Does the genetic modification of soy affect yields, either positively of negatively, compared with conventional soy varieties?

Reports from Canada, USA and Argentina indicate similar average yields of GM and conventional soy; a study in Mexico reports a yield increase. Field trial studies, though, report reduced yields from GM soy. This reduction is sometimes explained by the use of low quality seed material in the breeding of the GM soy. Evidence exists that the reduction is temporary in nature. The observed reduction in grain yield can also be explained by other factors, like insufficient water.

Differences in yield between GM soy and conventional soy are usually small. There is no evidence that GM soy produces yields that are structurally different from those of conventional soy.

2 GM soy changes the use of crop protection agents in soy and the environmental impacts from these agents

Herbicides are chemical compounds. They can be toxic to some plants and kill them when applied at the appropriate dosage. Some herbicides, called non-selective or broad spectrum herbicides, are toxic to a wide range of plants. Other herbicides target a single plant or small group of plants. Herbicides are used in agriculture as a chemical means to control the growth of weeds.

Does GM soy change the use of herbicides and the environmental impacts of these agents?

GM soy is resistant to the broad spectrum herbicide glyphosate. Glyphosate is used in conventional soy cultivation as a pre-emergence herbicide (i.e. it is active before the soy germinates). As conventional soy is affected by glyphosate, other herbicides have to be used in post-emergence stages. GM soy is resistant to glyphosate, which can therefore also be used while the soy plants are growing in the field. Data from the USA show that growing GM soy leads to a sharp increase in the use of glyphosate and a steep decline in the use of other herbicides, while the total use of herbicides (in kilograms of active ingredient) remains the same. A study in the North Buenos Aires–South Santa Fe soy cropping area in Argentina revealed higher herbicide use on GM soy than on conventional soy. However, this study also observed that the increased use of herbicides is caused by the higher application rates in the zero tillage system used for growing GM soy.

The overall environmental impact depends not only on the quantity of the herbicide used, but also on its toxicity. Two data analysis methods were used on data from the North Buenos Aires–South Santa Fe region to calculate and compare the impact of the use of herbicides on GM and conventional soy. The results imply that the changes in the use of herbicides resulting from switching from conventional to zero tillage and from conventional soy to GM soy both increase the environmental impact of soy cultivation. The change

in tillage system has the most significant impact. This was contradicted by a second study, which used one of the methods with partly different input data and included all soy growing regions in Argentina.

GM soy does lead to a strong change in the spectrum of herbicide use.
The environmental impacts of the herbicides used on GM soy are probably comparable to or higher than those of the herbicides used on conventional soy.

3 GM soy stimulates the development of herbicide resistance among weeds

Weeds have the ability to develop resistance to weed control methods, especially when a single agent is applied for a prolonged period of time. A shift in the weed control program eventually leads to a shift in the weed species composition, reflecting their resistance to the newly applied technology. A diverse weed control program is the best option in the long term.

Does GM soy have an effect on the development of herbicide resistance among weeds?

In Argentina and Brazil, cultivation of GM crops has led to persistent use of glyphosate herbicides and several glyphosate resistant weeds have evolved. Increasing weed resistance erodes the agronomic advantage of GM soy. There is evidence that some Brazilian farmers have responded by increasing application rates of herbicide. This would worsen the environmental impact of herbicide use.

Several options exist to diversify weed control programs and counter the risk of herbicide resistance building up in weeds. One is to include non-chemical methods, such as tillage. Another is crop rotation. A third option is to adopt the anticipated new GM soy with resistance to different herbicides. Resistance to some of these herbicides, used on either conventional or GM crops, has already been observed in weeds.

The introduction of GM soy probably contributed to the development of herbicide resistant weeds.

4 GM soy aggravates problems in the control of volunteer soybean in subsequent crops

Volunteer plants are individual plants from last year's crop growing in the field by natural propagation. They may become unwanted intruders in the present crop – called 'co-mingling'. They can introduce or spread diseases, and, if left unchecked, may become persistent cultivars around their original field.

Does GM soy affect the control of volunteer soybeans?

Whether volunteers appear depends on the method used to harvest the crop and prepare the field for the next crop. It also depends on the intrinsic properties of the plant, like the ability to resist seasonal weather conditions, to produce viable seeds banks, or to cross-fertilize with wild relatives. The extent to which seeds are eaten by birds or other animals is also important.

There is no evidence that GM soy causes problems in the control of volunteer crops.

5 GM soy facilitates zero tillage

Tillage is a farming technique that involves turning over the soil to prevent the growth of weeds and improve soil conditions, but it can cause erosion. In response, reduced or zero tillage practices were introduced to improve and sustain soil quality and soil water balance. They also deliver savings on machinery, labor and fuel inputs.

Does GM soy have an effect on the type of tillage practice used?

Grain-based agriculture (including soy, wheat and maize) is well-suited to zero tillage. Zero tillage was first used in Argentina in the 1960s, and from the 1980s was introduced into the southern states in Brazil, later spreading into the Cerrado region.

Zero tillage has several agronomic and environmental advantages, such as reducing soil water evaporation, improving water infiltration and higher soil carbon levels. Its disadvantages include soil compaction, increased soil acidity, and higher concentrations of pests and diseases. It may also encourage the cultivation of natural lands, like slopes and wetlands. It leads to more abundant weed growth, and this has been well documented for the Pampas area in Argentina.

GM soy is ideal for zero tillage because using the glyphosate herbicide on this crop reduces the need for mechanical weed control. In 2005, 87% of the total GM soy acreage in Argentina was cultivated using zero tillage, against 36% of the total soy area in 1996, when GM soy was first introduced.

GM soy encouraged the adoption of zero tillage, although it was already in wide use before the introduction of GM soy.

6 GM soy facilitates monocropping

Monocropping is a cultivation system in which a single crop is grown on the same piece of land for consecutive years. It is a common practice across the world and includes soy cropping in Latin America. Monocropping is generally considered to be a threat to the agronomic and economic sustainability of farming. It can encourage pests, diseases and weeds, and reduce soil fertility.

Does GM soy encourage monocropping?

Monocropping has been a common agricultural practice for many years and is not exclusively linked to herbicide-resistant GM crops. Prior to the introduction of GM soy, conventional soy and other crops like wheat and maize were already widely grown as monocrops in Brazil and Argentina.

Crop rotation – planting different crops in subsequent growing seasons – reduces disease pressure and improves soil fertility, and is widely recognized as integral to sustainable farming. When choosing between monocropping or rotation cropping, the agronomic features of rotation crops are important arguments for farmers, as well as the economic performance of the alternative crop.

Soy can be cultivated in rotation, for example with maize or wheat. Soy and wheat double cropping is also used. Nevertheless, soy monocropping is widespread. GM soy may facilitate monocropping because herbicides can be used on these crops quite easily. Compared with conventional soy, glyphosate can reduce weed pressure in the short term, but in the long term this may reverse as glyphosate-resistant weeds begin to appear.

Evidence of the role of GM soy in facilitating monocropping is inconclusive.

7 GM soy has an impact on biodiversity in and around agricultural fields

The biodiversity in and around agricultural fields consists of all the different plants, weeds, animals, microorganisms and other species that live there.

Does the use of GM soy have an impact on the biodiversity in and around the agricultural field?

The herbicides used on GM soy could cause a loss of biodiversity in and around the fields. Field margins and surrounding landscape are the prime concentrations of biodiversity in agricultural areas. If GM soy leads to an increase in field size and the scale of farming, field margins will be lost and landscape complexity will be reduced, or even disappear. An increase in the scale of operations may also encourage crop spraying as a preferred method for applying herbicides, and the resulting herbicide drift can further reduce the quality of field margins. Moreover, the efficient weed control programs often associated with GM soy can reduce the weed biodiversity in the agricultural fields. Weeds are a source of food for wildlife, but also a source of crop pathogens. In Argentina lower weed densities have been observed in GM soy fields than in conventional soy. However, it is not known what effect this has on the part played by the weed biodiversity in soy production or the agrosystem in general.

Alternatively, GM soy may benefit biodiversity in and around fields through the adoption of zero tillage, which often increases soil biodiversity. In turn this can benefit aboveground biodiversity as well.

GM soy probably has a different impact on biodiversity in and around fields than conventional soy.

8 GM soy is a threat to nearby farms that want to cultivate GM-free soybean

The agricultural landscape is a mixture of fields growing different crops. Where adjacent fields have different crops (or different varieties of one crop), measures to avoid cross-contamination may be needed to ensure purity levels in seed production, or guarantee product purity to give consumers a choice between conventional and organic, or between GM and GM-free. Over time, agriculture has developed a range of measures to keep crops in adjacent fields separate, called 'coexistence'.

Can coexistence be adequately managed with the introduction of GM soy?

How to avoid co-mingling of crops in the field depends largely on the pollination mechanism and the effectiveness of the prevention measure. Complete separation is not considered feasible. Certain threshold levels for impurities apply even to seed production.

Soy is mostly a self pollinator, and so can outcross over only very short distances. In fact, several studies have shown that this is limited to 5 to 10 meters. Preventing co-mingling with soy is therefore relatively simple and consists of introducing a small border area around a soy field.

Co-mingling may also occur during post-harvest stages. The shared use of agricultural equipment, storage, transport and processing facilities may lead to the mixing seeds of different soy varieties, and even with seeds of weeds and other crops. Setting up completely separate production and processing chains can prevent unwanted co-mingling.

The cultivation of GM soy does not pose a threat to nearby farms that want to cultivate GM-free soy. Appropriate measures should be taken to minimize outcrossing and herbicide drift, and to avoid mixing of seeds during field operations and in post-harvest activities.

9 GM traits in soy can spread and persist outside agricultural fields

Field crops have the potential to spread and persist in the surrounding areas, either through cross-fertilization with wild species or dispersal of reproductive material. This is undesirable, especially when an invasive crop becomes a pest.

Do GM traits in soy affect the spread and persistence of soy outside agricultural fields?

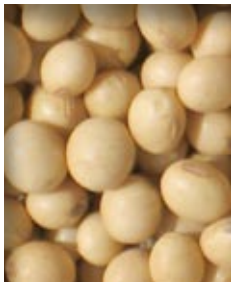
Several characteristics of a plant determine its ability to spread and persist outside agricultural fields: the mechanism of fertilization, its life cycle, and its nutritional value for other organisms. Important features of the receiving environment are the presence or not of related species the crop can cross-fertilize, and of plant predators, as well as the weather conditions.
Soy originates from East Asia, and there appear to be no related wild species in Latin America. Soy seeds are not dormant, which means they gradually lose their reproductive capacity over time.

In tropical climate conditions, soy can grow all year round. This should increase the viability of soy seeds, but predation and weed pressure appear to neutralize this.

It is highly unlikely that GM traits in soy spread and persist outside agricultural fields.

10 GM soy facilitates the expansion of soy production into natural areas

Expansion of soy production means that the acreage used for soy cultivation spreads out into other areas and replaces the previous land use.



Does GM soy facilitate the expansion of soy production, in particular into natural areas?

Soy production in Latin America has increased rapidly, from almost 30 million tonnes in 1990 to more than 110 in 2007. This increase is partly driven by an expansion of soy acreage. Between 1990 and 2007 the soy acreage in Brazil more than doubled to 22 million hectares, while in Argentina it tripled to more than 15 million hectares. Other factors include intensification of farming systems (e.g. double cropping) and other changes in agricultural practices.

The expansion of soy acreage occurs by replacing already existing agriculture, by converting grazing lands or natural areas into arable fields, or a combination of these, and shows wide regional variation. Weeds grow rapidly in tropical regions, and weed pressure is a limiting factor. It affects conversion to grassland as well as complicating the cultivation of soy in these areas. GM soy offers a convenient way of overcoming this drawback, with its easy to apply herbicide regime.

Soy expansion has resulted in biodiversity losses in Latin America. Studies on the cultivation of soy in Argentina show that GM soy introduced in the extra-Pampean region has replaced non-soy crops, whereas in the more moderate Pampean region it has replaced conventional soy.

GM soy may encourage the expansion of soy into particular natural areas during the initial years after their conversion into farmland.

11 GM soy affects the genetic diversity of soy varieties in Latin America

Genetic diversity is the variation in genetic composition between individuals within a species. Genetic diversity typically stands for the vitality of a species.

Does GM soy affect the genetic diversity of soy in Latin America?

Many different soy varieties are grown. Each variety has specific features that make it most suitable for specific regional conditions. Some characteristics may be introduced to meet specific market demands, like color, texture or nutritious content. The difference in characteristics between the varieties is reflected in the genetic variety that exists between them. The GM soy trait adds one more genetic element to the total genetic pool of the soy plant.

The GM soy trait can be bred into individual soy varieties by adding one character to the otherwise genetically diverse local varieties. There is no evidence that the genetic pool of soy has been reduced during the breeding of GM soy.

There is no evidence that GM soy has affected the genetic diversity of soy in Latin America.

12 GM soy changes the scale of farming in Latin America

The scale of farming normally refers to the land area of farms. The term is used as a (poorly defined) indicator of economic viability, the extent of monocropping, biodiversity in and around the fields, and the level of mechanization.

Does GM soy change the scale of farming in Latin America?

In Brazil and Argentina the scale of soy farming has increased, driven by the need for economies of scale to export soy at competitive prizes. GM soy is suitable for this up-scaling as the herbicide use associated with GM soy permits labor-extensive cultivation methods and reduces production costs per acre.

In Brazil, large-scale soy production began well before the introduction of GM soy. However, in Argentina, the growth in large-scale farming coincided with the introduction of GM soy. At the same time, other developments also had an impact, such as the shift to a free market, changes in farm policies and the introduction of external economic actors.

GM soy probably facilitated an increase in the scale of farming, but the availability of GM soy was not a decisive factor in this process.

The next steps

The outcomes of the GM Soy Debate so far provide the first stepping-stones for a constructive debate. There is a widely felt need to further internationalize the GM Soy Debate and include an assessment of the socioeconomic impacts of GM soy in future work. The GM Soy Debate initiative is currently planning successive projects addressing sustainability issues related to the cultivation of GM soy.

Copies of this publication and the original research report can be downloaded from the GM Soy Debate website, which will continue to serve as a forum for debate and the exchange of information. It hosts a discussion forum for comments on the project's publications and suggestions for the organization and focus of future activities.

We welcome the input and participation of all stakeholders.

About this publication

The GM Soy Debate is an initiative by Solidaridad and WWF Netherlands, and is supported by the Development Policy Review Network (DPRN), Solidaridad, WWF Netherlands and the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM). The project is run by Plant Research International B.V. (Wageningen University and Research Centre) and Aidenvironment.

For further information on the GM Soy Debate initiative, please visit the project's website: http://gmsoydebate.global-connections.nl/ or contact the facilitator of the project by e-mail: gmsoydebate@global-connections.nl

For maximum outreach to all relevant stakeholders, this publication is available in English, Spanish and Portuguese.

GM Soy Debate, 2009