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# Current and future availability of non-genetically modified soybean seeds in the U.S., Brazil and Argentina

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## Abstract

The high GMO adoption rates in the U.S., Brazil, and Argentina, the leading countries in soybean production, have raised the question of whether non-GM varieties will continue to be developed for farmer uses (i.e. whether new competitive non-GM varieties will be bred and released). This article outlines the current status of the soybean seed market and plant breeding for these three leading producers of soybeans. The focus on research and development of new soybean varieties in countries with different GM soybean adoption rates, and different economic and legal contexts, also provides new insight into how the development of a GM culture, of any species, might exclude the development of the alternative non-GM culture of the same crop.

**Keywords:** seeds, soybean, non-GM soybeans, plant-breeding, market concentration, path-dependency.



# 1 Introduction

The high GMO adoption rates in the USA, Brazil and Argentina, the leading countries in soybean production, have raised the question of whether non-GM varieties will continue to be developed for farmer uses (i.e. whether new competitive non-GM varieties will be bred and released). This issue gained prominence in 2009, when anecdotal information revealed that some U.S. farmers had difficulties accessing non-GM soybean seeds. The aim of this chapter is to outline the current status of the soybean seed market and soybean plant breeding for the three leading soybean producers, and to discuss to whether the apparent 2009 seed shortage in the U.S.A. is just a short-term issue or whether it reveals a more general, strong decline of competitive non-GM seed breeding and supply.

Investigations of non-GM soybean seeds availability in the Americas are of interest to the European Union (EU) because they provide insight into the issue of future non-GM soybean supply in these countries. Europe depends on soybean imports, and the future availability of non-GM materials for feed uses (e.g. linked to labelling policies) is an important source of debate. Issues like identity preservation in the supply chain have been addressed in other publications, but the question of the availability of non-GM seeds for farmers in exporting countries has not yet been investigated. This focus on research and development of new soybean varieties in countries with different GM soybean adoption rates and different economic and legal contexts also provides insight into whether the development of a GM culture of any species within in a country might exclude the development of the alternative non-GM culture of the same crop, and can help us understand the mechanisms that may drive this process (a process called ‘path-dependency’ (Vanloqueren and Baret, 2009).

Methodologically, this report gathers information from a number of sources.

- data from variety registers or from databases of intellectual protection rights in the three countries (e.g. certificates or patents on varieties);
- phone or e-mail interviews with actors of the sectors considered in the three countries (e.g. researchers, plant breeders, farmers, firms or non-profit organization employees, civil servants, or journalists);
- an Internet search of companies’ public documents (e.g. variety catalogues);
- scientific and gray literature.

The first section of the report gives an overview of the world GM and non-GM soybean market. It describes current non-GM soybean production and the current demand for non-GM soybean seeds in the USA, Brazil, and Argentina - the three countries under consideration. The second section presents the different types of intellectual property rights for plant breeders, the market structure in the soybean seed industry, the non-GM soybean breeding activity, and the availability of non-GM seeds for farmers in each country. The third section discusses prospects for the future of non-GM soybean breeding activity.

## 2 Global overview of the soybean and soybean seed markets and related short-term issues

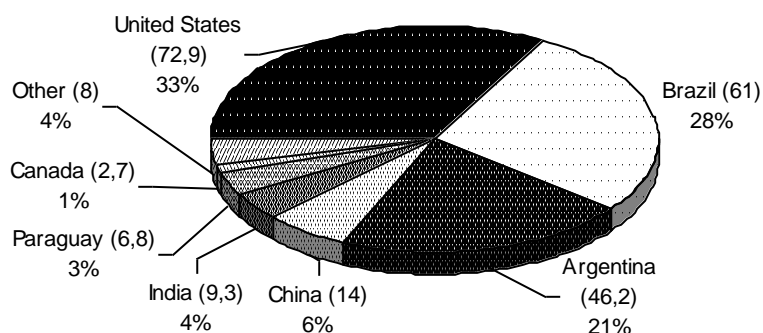
This section provides an overview of the global soybean market and a presentation of the non-GM soybean seed market in the U.S.A., Brazil, and Argentina. It includes a special focus on the shortage of non-GM soybean seeds that occurred in the U.S.A. in 2009.

## 2.1 Global soybean market

This subsection gives a rapid overview of global soybean supply and demand.

### 2.1.1 Global market

The United States, Brazil, and Argentina are the world soybean production leaders. In 2008, they accounted for 82% of the 220.9 million tonnes of global production of (see Figure 1).



**Figure 1: World soybean production in 2008, in millions of tons and % of the world production (Data from USDA and ASA, 2009)**

While production has been quite stable in the USA in the last decade, it has risen significantly in Argentina and Brazil. This increase is primarily because of the increase in GM varieties, which now dominate these markets.

The average adoption rate of transgenic soybeans in these three countries rose from 11.2% in 1997 to more than 85% in 2008, with significant differences between the three countries. Almost all Argentinean soybeans are transgenic, while 45% of Brazilian soybean areas are still planted with conventional varieties. The United States are in between, with 8 to 9% of the surface planted with conventional soybeans (see Figure 2, 3, and 4).

Soybeans are mainly used for oil and meal production. Soybean oil represents 30% of world vegetable oil consumption and soybean meal 68% of world protein consumption (ASA, 2009). Industrial uses are also increasing, such as use of soybean oil to produce biodiesel in the U.S.

The increase in soybean production is mainly driven by increasing demand in developing countries. Higher incomes and rapid population growth generate higher demand for vegetable oil for human food and meal for protein for livestock production. Chinese imports have been rising strongly since the beginning of the century, and this trend is expected to continue in the coming years (USDA, 2008). Soybean prices increased considerably during the 'world food price crisis' of 2007-2008, and were still at a high level in July 2009 (398 USD per tonne at the Chicago Board) after a major decrease in 2008.

### 2.1.2 Non-GM market

Due to the reluctance of consumers, mainly in Europe and Japan, to eat GM products or products from animals fed with GM materials, a non-GM soybean market with identity preservation (IP) has been developing since the beginning of the decade.

#### 2.1.2.1 Different types of non-GM soybeans

The non-GM soybean market is composed of different product types, with various characteristics, offering premiums to producers. It is mainly divided between soybeans for general use and soybeans with special traits (low and ultra-low linolenic soybeans, high protein, etc.).

### 2.1.2.2 Production of non-GM soybeans

According to ABRANGE, the association of producers of non-GM soybeans, Brazil is producing approximately 53% of the world's non-GM soy, followed by India and China; countries that produce 18 and 17% of the world's non-GM crop, respectively (see Table 1).

| Country      | Millions of tonnes |
|--------------|--------------------|
| Brazil       | 25 000 000         |
| India        | 8 500 000          |
| China        | 8 000 000          |
| Others       | 5 500 000          |
| <b>Total</b> | <b>47 000 000</b>  |

**Table 1 Non-GM soybean production in volume – 2009 Estimated (Data from Abrange, 2009)**

These estimations, however, did not include the increase in non-GM production in the U.S. in 2009. According to the estimated surface planted, the total production of non-GM soybeans in the U.S. may represent around 7 million tonnes in 2009 (see below).

### 2.1.2.3 Demand for non-GM soybeans

The demand for non-GM soybeans originates mainly from Europe and Japan. In Europe, this demand is driven by the production of animals fed with non-GM soybeans. Until now, this demand has been restricted to quality products, like 'Label-Rouge' animal products in France (Milanesi, 2008). However, demand for non-GM soybeans may rise in the future due to changes in German labelling policies (since the first of June 2008, German law authorizes labelling for products from animals fed with non-GM soybeans) and similar changes that may soon occur in France. These labelling changes in France and Germany (the first and third largest agricultural producing countries in the EU) consolidate the non-GM policies of producers who have already adopted this production choice and may give incentives to others to change their practices. These producers are indeed paying a premium for non-GM soybeans (Milanesi, 2008), coming primarily from Brazil. Labelling allows them to value this policy and to transfer the extra costs to consumers. European demand for non-GM soybeans could therefore either stay at the same level (about 1 million tonnes for France in 2007 (Milanesi, 2008)) or even increase in the coming years, depending on consumer reaction to labelling.

Japan is the other important market for non-GM soybeans, mainly for food uses (e.g. tofu, natto, miso, soymilk, or soy sauce). All Japanese companies producing soy-food require non-GMO varieties from their suppliers (The Organic & Non-GMO Report, July 2006). In 2005, Japanese demand totalled about one million tonnes of soybeans for food uses (Reuters, 9<sup>th</sup> of March 2005). Around 80% of these soybean imports were from the U.S.,<sup>1</sup> and they were sold with a price premium.

## 2.2 Production of non-GM soybeans in the U.S. and shortage of non-GM soybean seeds

The U.S. is the world's leading soybean producer, representing one third of global production in 2008 (see Figure 1). After corn (34.4 million hectares planted in 2009), soybean is the second most common U.S crop produced, in terms of planted area (ERS/USDA). Soybean production is mainly located in the Midwest and in the Mississippi valley. Maturity groups<sup>2</sup> of varieties range from 00 in

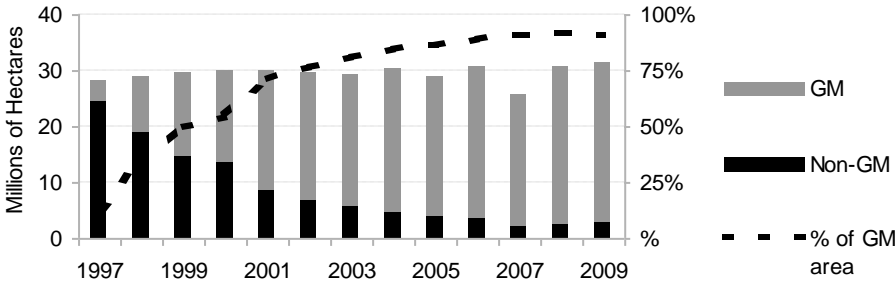
<sup>1</sup> The Organic and non-GMO report, November 2008.

<sup>2</sup> 'As soybean breeding developed in the United States and Canada, it became a general practice to group soybeans according to their photoperiod response and general area of adaptation. Thirteen maturity groups (MGs)

the North to VII-VIII in the South (to V for the most commonly used). More U.S. farmers decided to grow non-GM soybean in 2009, as a result of changes in the relative profitability of GM and non-GM varieties. Because seed producers did not expect this increase, there was a shortage of non-GM seeds in some States. This problem of quantitative availability of non-GM seeds should be solved next year by an increase in seed production. The following subsection details the main drivers of this increase in non-GM soybean plantings and of the subsequent seed shortage.

**2.2.1 An increase in non-GM production**

The non-GM soybean area in the U.S. increased by one million acres in one year, from 5.96 million acres (2.4 million hectares) in 2008, to 6.97 million acres (2.8 million hectares) in 2009.<sup>3</sup> After over a decade-long decrease in the non-GM area, this figure confirms the initial slight increase that occurred in 2008 (see Figure 2).



**Figure 2: GM and non-GM soybean planted area in the U.S., in hectares (Data from USDA/FAS, March 2009)**

As a result, the share of non-GM soybean plantings increased in 2009 for the first time since 2000. Non-GM soybeans accounted for 9% of a record high 31.4 million hectares of soybeans planted in 2009. In 2008, non-GMO soybeans accounted for 8% of 30.6 million hectares of soybeans. This global increase in non-GM plantings may be explained by new economic conditions on GM and non-GM soybean cultivation: high premiums for non-GM soybeans and an increase in the production costs of GM soybeans.

**2.2.1.1 Premium for non-GM soybeans**

Premiums are paid to U.S farmers for several types of non-GM soybeans that are grown for feed or human food use. According to non-GM grain traders these premiums varied in 2009 from one to 2.75 USD per bushel (36.8 USD/tonne to 101.1 USD/tonne)<sup>4</sup>. These premiums are high relative to commodity prices that ranged from 330 USD/tonne to 430 USD/tonne in the previous year. In a context where soybean commodity prices were decreasing at the end of 2008 and in the beginning of 2009, these premiums created a major incentive for farmers to grow non-GM soybeans.

**2.2.1.2 Increase in the production costs of GM soybeans**

Farmers or sector specialists often quote the increase in the cost of Roundup Ready® (RR) seeds as an influential rationale for the soybean growers’ decision of which variety to sow. The average cost of GM seeds per acre has more than doubled since the beginning of the decade (Bonny, 2009). The relative competitiveness of Roundup Ready seeds versus non-GM varieties was also

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are now recognized (...) starting with "000" for the earliest maturity group adapted to the long days and short summers of southern Canada and northern United States, and ending with "X" for the latest maturity group, which is adapted to the short days of tropical regions on either side of the equator.’(Alliprandini et al., 2009)

<sup>3</sup> Data from USDA.

<sup>4</sup> Personal communications with non-GM soybean traders.

hindered by the recent increase in the price of glyphosate herbicides. After several years of decline caused by the emergence of generic brands, followed by price stabilization in recent years, the price of glyphosate finally rose in 2009 (Bonny, 2009).

The cost of using Roundup Ready soybeans is also increasing because of the development of glyphosate-resistant weeds. The high increase in glyphosate use in the U.S. linked to the spread of Roundup Ready varieties ‘has led to the appearance of weeds resistant to this herbicide. Glyphosate resistant weeds have already appeared in the U.S. in different states (nine weeds at the end of 2008), as well as elsewhere in the world (sixteen weeds in total at the end of 2008)’ (Bonny, 2009). Farmers therefore must use more glyphosate and other herbicides to control the resistant weeds. This results in additional cost that reduces the agro-economic advantage that Roundup Ready varieties provide to farmers.

## **2.2.2 Reduction in distribution channels and problems of production planning**

Because the number of farmers choosing to plant non-GM soybeans suddenly increased in 2009, the demand for non-GM seeds also increased. As a result, some seed sellers sold out of these varieties. John Suber, who runs Ebberts Field Seeds in western Ohio, explained that ‘he was surprised when he sold out of non genetically modified soybean seed’ before January.<sup>5</sup> James Orf, a plant breeder from a state university, has collected the same kind of testimony in Minnesota.<sup>6</sup> According to one of their executives, Pioneer, one of the market leaders, did not sell out its non-GM seeds but was close.<sup>7</sup>

The characteristics of seed production explain these shortages. Production must be planned at least one year before selling, and at the beginning of 2008, after years of rising demand for GM seeds, seed producers did not predict the significant increase in demand for non-GM seeds in 2009. Moreover, soybean seeds are very fragile and cannot be stored easily, making it difficult to adapt soybean seed supply to sudden demand changes through the use of seed stocks. In anticipation of another demand increase in 2010, some non-GM seed producers decided to multiply their production two or threefold.<sup>8</sup> Barring emergent problems in seed distribution, the situation may return to normal in 2010.<sup>9</sup>

## **2.2.3 U.S. farmers face difficulties finding non-GM soybean seeds**

The process of seed production planning, and possibly distribution, created a decrease in non-GM seed availability for U.S. farmers in 2009. It seems, however, that this situation actually began in 2008, the first year that a (slight) increase in non-GM acreage was observed (see above). The *Non-GMO and Organic Report*, a newsletter on organic and non-GMO issues, ran an article in summer 2008 entitled ‘Finding non-GMO soybean seed becoming more difficult’ as the headline of an article in which Jim Skiff, the president of the U.S. Soy company, reported a shortage of non-GM soybean

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<sup>5</sup> WCPN radio, May 28 2009, <http://www.wcpn.org/WCPN/news/26357/>

<sup>6</sup> Personal communication with James Orf, Professor of agronomy and plant genetics, University of Minnesota, 31<sup>st</sup> of July 2009.

<sup>7</sup> Personal communication, 28<sup>th</sup> of July 2009.

<sup>8</sup> WCPN radio, May 28 2009, <http://www.wcpn.org/WCPN/news/26357/> or Corn and Soybean Digest, 14<sup>th</sup> of April 2009, (<http://cornandsoybeandigest.com/soybeans/0414-non-biotech-soybean-interest/>)

<sup>9</sup> Indeed, the view has been expressed that the distribution of conventional seeds is also decreasing because ‘independent seed dealers have affiliated with large companies’ who would prohibit them from selling such seeds (Organic and non-gmo report, July 2008), an analysis that would need confirmation by further investigation.



seeds. The problem of the availability of non-GM soybean seeds in the U.S. market heightened significantly in 2009, however. Several different newspapers and specialised websites in a number of U.S. states reported that farmers faced difficulties finding non-GM seeds.

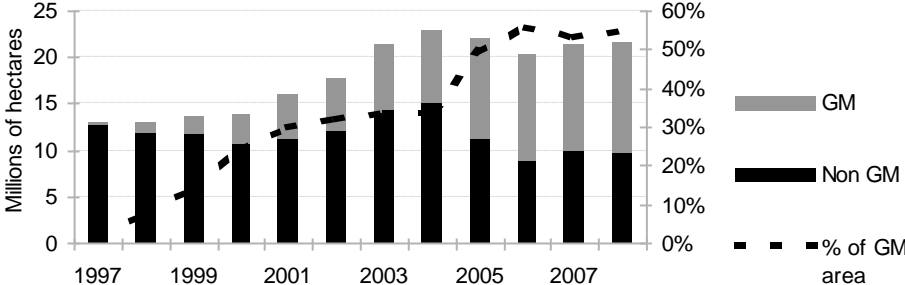
Real seed shortage certainly varied by State and, as previously outlined, real tensions first appeared in the non-GM seed market in spring 2009. According to the information and data gathered, these tensions resulted more from a problem of quantity, due to insufficient seed production, than from a quality problem, of global availability of diversified and competitive non-GM seeds. This latter issue is addressed in the following section.

**2.3 Brazil: the world’s leading producer of non-GM soybeans**

With a production of 61 million tonnes in 2008 (USDA), Brazil was the second largest soy producer in the world. That same year the major destinations for Brazilian soy were the EU-27 (European Union), who imported 44% of Brazil’s soy. Eastern Asia imported another 38%, Southeast Asia imported 6%, and other European countries, the Middle East, and North Africa each imported another 2% (SECEX/MDIC, 2009).

Brazil’s production is mainly located in five southern and central states. Between 2001 and 2005 Mato Grosso produced 29% of the national production, Parana 18%, Rio Grande do Sul 13%, Goias 12%, and Mato Grosso do Sul 8% (source: USDA). Soybean varieties used in Brazil range from maturity group V to X (Alliprandini, 2009).

After permission to trade in GMOs in Brazil was granted in 2003, the soy industry divided itself into at least two different segments: conventional soy and GM soy. The share of area planted with GM varieties has been quite stable at around 55% since 2006 (see Figure 3), though this figure differs among states (95% in Rio Grande do Sul, 50% in Parana, and 60% in Mato Grosso do Sul<sup>10</sup>).



**Figure 3: GM and non-GM soybean planted area in Brazil, in hectares (Data from CONAB, ASA, USDA and ISAAA, 2009)**

According to Cert-ID in 2009 ‘roughly 26 million tonnes of non-GM soy (i.e. 45 to 50% of Brazil’s total soy harvest of 57.3m tonnes) was non-GM. Although lack of demand led most of this non-GM soy to be sold without segregation and traceability, some 10 million tonnes were produced within IP systems, certified GM-free below a detection limit of 0.01%, and were available for purchase by European buyers. Furthermore, 6.3 million tonnes of this were additionally certified via the ProTerra standard as both non-GM and sustainable, and were sold and shipped as such.’<sup>11</sup>

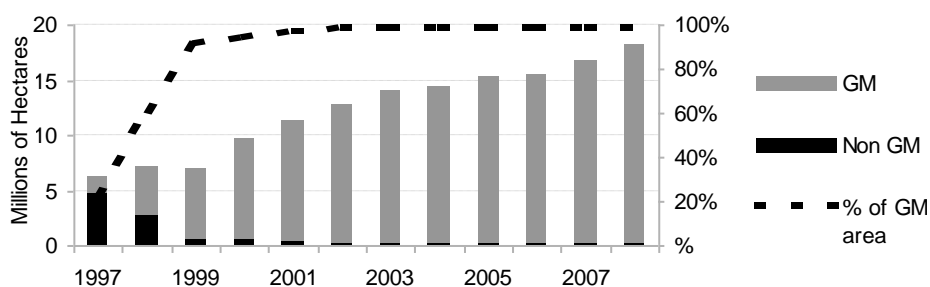
<sup>10</sup> Source: Embrapa, Imcopa

<sup>11</sup> <http://www.cert-id.eu/ProTerra.php>

## 2.4 Argentina: small-scale production of non-GM soybean

Argentina is the world's third-largest producer of soybean and the largest exporter of soybean meal and oil (USDA, 2008). Soybean growing has developed in Argentina primarily since the 1990s, and is mainly located in the regions of Cordoba, Santa Fe, and Buenos Aires. The diverse climate in these areas allows the use of soybeans from maturity groups II to IX (INTA).

The development of soybean production has been based mainly on glyphosate-resistant GM soybeans. Non-GM soybean production in Argentina has represented only about 1% of total soybean production in the country for several years (see Figure 4).



**Figure 4 : GM and non-GM planted hectares of soybean in Argentina (Data from ArgenBio, ASA, USDA and ISAAA, 2009)**

Most of these non-GM soybeans are produced for food use, for local consumption, or for exportation. A very tiny organic production also exists, and represents less than 10,000 ha (i.e. less than 0.1% of total soybean production).<sup>12</sup>

## 3 Soybean plant breeding and availability of non-GM soybean seeds

This section describes the evolution and the current situation of non GM soybean seed availability in the United States, Brazil, and Argentina using an assessment of soybean breeding activities in these countries. We begin with a focus on the different legal frameworks relating to Intellectual Property Rights for plant breeders. We then detail, for each country, the soybean seed industry structures and the companies and public actors that continue to perform non-GM soybean breeding programs and provide non-GM varieties.

### 3.1 Intellectual Property Rights for plant breeders in Argentina, Brazil, and the U.S.

The nature and scope of Intellectual Property Rights (IPRs) on plant varieties have a major influence on plant breeding activity.

IPRs 'give the creator the right to prevent others from making unauthorized use of their property for a limited period.' The main IP rights used to protect plant varieties are patents and plant breeders' rights (PBRs). A patent is 'an exclusive right awarded to an inventor to prevent others from making, selling, distributing, importing or using their invention, without license or authorization, for a fixed period of time.' PBRs 'are granted to breeders of new, distinct, uniform and stable plant varieties. They normally offer protection for at least fifteen years (counted from granting). Most

<sup>12</sup> Source: SENASA, <http://www.senasa.gov.ar/contenido.php?to=n&in=786&io=2946>

countries have exceptions for farmers to save and replant seeds, and for the use of protected materials for further breeding' (USFD, 2007).

The convention of the International Union for the Protection of New Varieties of Plants (UPOV) guarantees reciprocity between signatories on protection of new varieties. It was adopted in Paris in 1961 and revised in 1972, 1978, and 1991, with different provisions (Fuck et al., 2008).

The U.S., Brazil and Argentina have specific laws on plant variety protection and have signed the UPOV convention. Of the three countries under study, only the U.S. authorizes patents on plant varieties. The IPR of plant breeders in Argentina and Brazil have, however, been challenged in recent years by the development of a large-scale parallel black market.<sup>13</sup> Table 2 summarizes the main characteristics of plant variety protection in the three countries.

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<sup>13</sup> See for instance Fuck et al. (2008), Kesan and Gallo (2005), or Rapela et al. (2006)

|           | Plant variety protection                 |                    |                             |                     |   | Possibility of patents for plants |
|-----------|--|--------------------|-----------------------------|---------------------|---|-----------------------------------|
|           | Year of adherence to UPOV                | Farmers' privilege | Essentially derived variety | Breeder's exemption | Protection period (years)               |                                   |
| Argentina | 1994 (1978 Act)                          | Yes                | No                          | Yes                 | 20                                      | No                                |
| Brazil    | 1997 (1978 Act and elements of 1991 Act) | Yes                | Yes                         | Yes                 | 15 temporary crops / 18 permanent crops | No                                |
| USA       | 1994 (1991 Act)                          | Yes                | Yes                         | Yes                 | 20                                      | Yes                               |

**Table 2 : Comparison of plant variety protection systems in Argentina, Brazil and USA (Source: Fuck et al. (2008), Fernandez-Cornejo (2004))**

### **3.2 Non-GM breeding and seeds in the U.S.**

Due to the recent shortage of non-GM seeds (see section 2.2.3), the availability of competitive non-GM varieties, in terms of phenotypic diversity, has emerged as a topic of interest in the U.S. soybean farmer community. The objective of this section is to examine whether the available data on non-GM soybean breeders activity and on non-GM varieties available to farmers corroborate this apparent decrease in non-GM breeding activity.

Because the seed industry has substantially changed over the past two decades, resulting from mergers and acquisitions, and because no recent synthetic data is available on the structure of the soybean seed industry, the first part of this sub-section will be dedicated to an analysis of the market concentration of the soybean seed industry. The second part will be dedicated to an assessment of the main companies and universities still breeding non-GM soybean varieties for farmers. The analysis of their lineup will then be used to give an overview of the non-GM varieties currently available to farmers.

#### **3.2.1 Market concentration**

Deputy Assistant Attorney General Phil Weiser announced in August 2009 that ‘the Antitrust Division [was] planning to look, in cooperation with the USDA, into the state of competition in agriculture markets’. He added that they ‘understand that there are concerns regarding the levels of concentration in the seed industry--particularly for corn and soybeans.’<sup>14</sup> Concerns about high concentration in the soybean industry may be understood by examining mergers and acquisitions in the sector as well as concentration in the soybean seed market, in soybean breeding activity and in germplasm ownership.

##### **3.2.1.1 Mergers and acquisitions (M&A) in the soybean seed industry**

Widespread literature exists about the seed industry and its concentration process. Jorge Fernandez-Cornejo (2004), in the most complete study to date of the U.S. seed market, traces the evolution of the major seed companies. Similar information can also be found in the AgBioForum special issue ‘Innovation and dynamic efficiency in agricultural biotechnology’ (Volume 8, number 2

<sup>14</sup> <http://www.usdoj.gov/atr/public/speeches/248858.htm>

&3, 2005) and particularly in the article by Pray, Oehmke and Naseem which states that 32 mergers and acquisitions occurred in the world soybean seed industry between 1988 and 2002.<sup>15</sup>

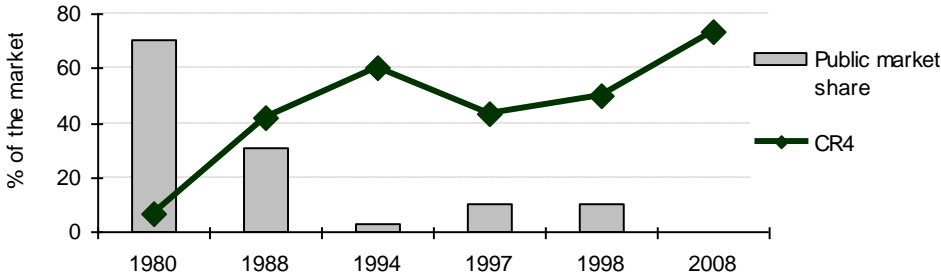
**3.2.1.2 Concentration of soybean seed sellers**

The market shares in soybean seed sales provided the first evidence for the extent of increased market concentration brought about by mergers and acquisitions among seed companies. According to Fernandes-Cornejo (2004), ‘the development of soybean seed varieties was dominated by the public sector until the 1980s. (...) In 1980, over 70 percent of soybean acres harvested in the United States were planted with publicly developed varieties, but by the mid-1990s, the public share had decreased to as low as 10 percent of the market.’

The most recent official data existing on market share of soybean seed companies in the U.S. is for 1998 (Fernandez Cornejo, 2004). More recent data, gathered from firms’ annual reports or news releases, show an increase in the market share of market leaders, as follows:

- Monsanto with its American Seed subsidiary, a grouping of regional seed businesses, estimates that their market share in 2008 was 29%;<sup>16</sup>
- Pioneer’s market share ranged from about 25-30% in recent years, according to various news releases;<sup>17</sup>
- Syngenta (formerly Novartis) purchased Golden Harvest and Garst Seeds in 2004. Their soybean market share ‘has been estimated at 13-13.5% at a couple of points between 2005 and 2008’.<sup>18</sup>

Assuming that in 2004, like in 1998, there was a fourth company with a market share of 4%, the evolution of the Concentration Ratio (CR4) can be traced continuously from 1980 to 2008 (see Figure 5).



**Figure 5 : Estimation of the evolution (in %) of market shares for soybean seed varieties, for public breeders and for the four market leaders (Data from: see text)**

The Herfindahl-Hirschman Index (HHI),<sup>19</sup> calculated for 2008 with the market shares of the top four companies, reaches 1782 points. It would be higher and would most certainly rise above the 1800 point level of if market share data of other companies were included. This HHI index is used by the Antitrust Division of the U.S. Department of Justice to evaluate the level of concentration of a

<sup>15</sup>Fulton M. and Giannakas K. (2001) and the Canadian non-profit group ETC (2005, 2008) also published detailed information on subsidiaries and acquisitions of the main seed companies

<sup>16</sup> 20% for Asgrow and a 9% market share for ASI. Source: Paul Heisey (USDA), personal communication.

<sup>17</sup> Pioneer claim in various press releases that they are the market leader for soybean seeds, which means that they sell more than Monsanto (29%) or Asgrow (20%). Some press releases suggested that they may have been estimating a market share of about 25% in 2006 or 2007. The company also claimed in 2008 that they had gained six market share points over the last eight years, and three more points in 2009.

<sup>18</sup> Source: Paul Heisey (USDA), personal communication, 29<sup>th</sup> of July 2009.

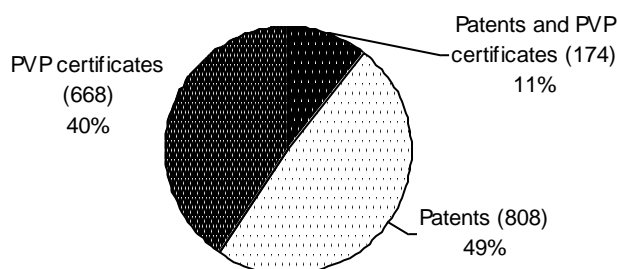
<sup>19</sup> "HHI" stands for the Herfindahl-Hirschman Index, a commonly accepted measure of market concentration. It is calculated by squaring the market share of each firm competing in the market and then summing the resulting numbers.

market: ‘Markets in which the HHI is between 1,000 and 1,800 points are considered to be moderately concentrated, and those in which the HHI is in excess of 1800 points are considered to be concentrated.’<sup>20</sup> The figure calculated here is therefore consistent with the recent statement by the Deputy Assistant Attorney General Phil Weiser, concerning the Antitrust Division’s interest in the corn and soybean seed markets.

### 3.2.1.3 Analysis of patents and PVP certificates on soybeans

The data on market shares of seed sales presented above does not necessarily reflect the concentration of plant breeding activity. The Federal Trade Commission is now looking at competition at the innovation stage, to assess concentration and the impact of mergers in the seed sector.<sup>21</sup>

R&D expenditures are generally not available to assess innovation competition (that is, competition in research activities). Data on IPRs have therefore been used as a proxy in recent years to measure research efforts in the seed sector. Several authors used patent databases for studies focusing on biotechnologies (Pray et al., 2005; Schimmelpfennig et al, 2003; Brennan et al, 2005), while others used databases on patents and Plant Variety Protection (PVP) certificates to study a particular crop, such as corn (Nolan and Santos, 2009). Nolan and Santos (2009) suggested that ‘the share of ownership of germplasm, as an essential input for modern varieties of corn, could be used as a proxy measure of market concentration in the corn seed market.’ They used ‘data from the databases of the United States Patent and Trademark Office (USPTO) and the United States Plant Variety Protection Office (PVPO)’. The same methodology is used below to evaluate concentration in the U.S. soybean breeding industry. In this case, a specific database has been built on patents and PVP protection of soybean cultivars, issued between 1990 to 2007<sup>22</sup>. The database is then used to evaluate concentration of soybean germplasm property at the end of 2007.



**Figure 6 : Database on IPR on soybean germplasm resources in 2007 (Data from USDA and PVPO, 2009)**

This data can be analyzed as a stock or as a flow. The stock of IPR in 2007 (Figure 6) represents the protected germplasm resources existing in the U.S. in 2007 (i.e. all soybean varieties protected at the end of 2007 by a PVP certificate and/or a patent). This data shows the ownership of recently protected germplasm resources for soybeans. The flow of IPR is the number of PVP certificates or patents issued per year on soybean varieties. This flow provides insight into the annual soybean breeding activity and about the relative use of patents or PVP certificates per year or per company.

#### 3.2.1.3.1 Concentration of soybean breeding activity

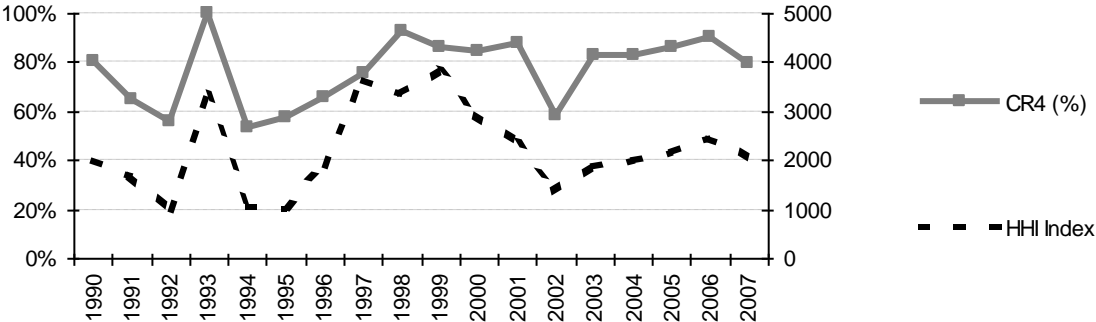
<sup>20</sup> <http://www.usdoj.gov/atr/public/testimony/hhi.htm>

<sup>21</sup> Fulton M. & Giannakas K., 2001, p.138

<sup>22</sup> The patent data on soybean cultivars originates from the USPTO database (Pray et al., 2005 and Paul Heisey (USDA), personal communication). The PVP certificates data for soybean have been extracted from the PVPO listing (Downloaded on 29<sup>th</sup> June 2009 from the PVPO website).

The first patent on a soybean variety was issued in 1986 (this first patent expired at the end of 2007) for the company DeKalb Pfizer Genetics, though most soybean patents were granted after the mid-1990s. Patents have significantly increased since that time, to a high of 159 in 2007, while PVP certificates remain between 20 and 80 varieties issued per year (except for a high of 134 in 2001). The number of soybean varieties with IPRs has therefore significantly increased since the beginning of the century. This may have resulted from an expansion of research efforts on this plant and/or an intensification of the use of intellectual protection.

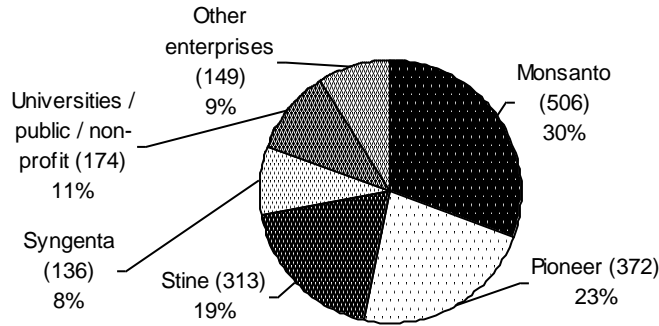
The number of assignees per year helps determine the number of plant breeders working on soybean varieties. 77 companies, universities, or diverse institutions have protected at least one new soybean variety with a PVP certificate or a patent since 1990, with a maximum of 21 in a single year (1995). After a significant decrease in the number of private companies that protected varieties each year, due to mergers and acquisitions, new entrants into the market reversed this trend. Eight private companies were protecting soybean varieties in 2007, which is as many as in 1996 or in 1992. Provided IPR data properly reflects plant breeding activity, the data does not indicate any decrease in the number of soybean breeders. New entrants, however, are small enterprises with a low “market” share and soybean breeding activity is highly concentrated in the top four companies (Monsanto, Stine, Pioneer, and Syngenta). This high level of concentration is confirmed by the HHI index, which has ranged from 1900 to more than 3800 points since 1996 (except in 2002, when it dropped to 1300 points, see Figure 7).



**Figure 7: Concentration in the US soybean seed industry. CR4 and HHI on variety registration activity (Data from USDA and PVPO, 2009)**

3.2.1.3.2 Concentration of germplasm ownership

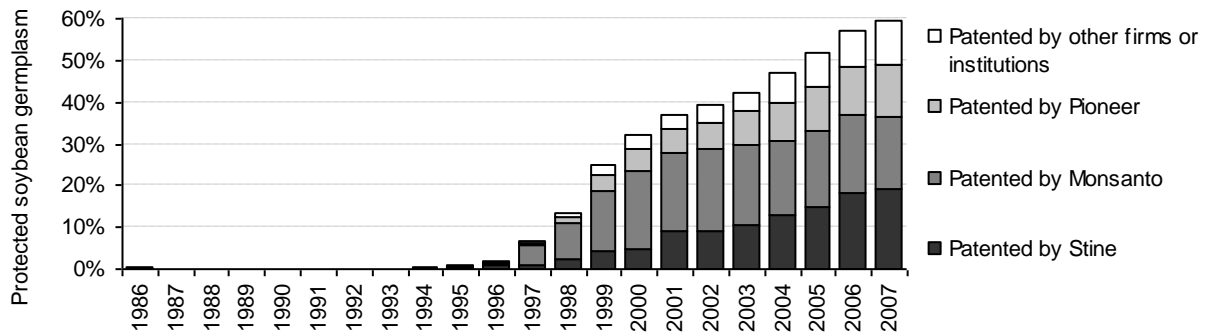
The data on the ownership (stock) of germplasm resources give complementary information on the level of concentration of the soybean breeding industry. If no merger and acquisition had taken place between 1990 and 2007, the data indicate that the concentration ratio (CR4) of soybean germplasm resource ownership in 2007 would have been 61.7% and the value of the HHI index would have been 1155.7. Including actual mergers and acquisitions in the calculation, the CR4 reaches more than 80.4%, meaning that the top four firms (Monsanto, Pioneer, Stine and Syngenta) own more than 80% of U.S. soybean protected germplasm resources (see Figure 8). Public and non-profit institutions own 10.5 % and 17 other enterprises share the remaining 9% of these resources. The HHI index confirms this high level of concentration with a value of 1958.7 points.



**Figure 8 : Ownership of soybean germplasm resources in 2007, number of patents and PVP certificates and percentages per company (Data from USDA and PVPO, 2009)**

Mergers and acquisitions in the seed industry therefore had an important impact on concentration of recent soybean germplasm ownership. But the impact of this germplasm resource concentration on soybean breeding activity itself depends on the type of IPRs used by the largest firms. The IPR policy differs between companies. Stine only uses patents to protect its varieties while Pioneer and Monsanto are using both patents and PVP certificates. Universities and public or non-profit organizations mainly use PVP certificates.

As private companies are patenting more varieties every year, the share of patented soybean germplasm resources is increasing. This percentage rose from 0% in 1985 to 60% in 2007 (see Figure 9).



**Figure 9: Percentage of protected soybean germplasm resources patented (Data from USDA and PVPO, 2009)**

The values presented in Figure 9 show that in 1985, a plant breeder had free access to all the U.S. soybean germplasm resources in order to perform his plant crosses. As the use of patents has increased, the share of freely accessible recent soybean germplasm resources<sup>23</sup> has fallen, from less than 80% in 1999 to below 50% in 2005. In 2007, there was free access to only 40% of protected soybean germplasm resources for plant breeding. Plant breeders from small companies and universities are the most affected by this decrease in free-access germplasm resources. Indeed, the patents are owned by a handful of large companies: in 2007, four companies (Stine, Monsanto, Pioneer and Mertec) owned around 90% percent of the patents on soybean germplasm, while the fifth company, Syngenta, had a 6% share. The value of the HHI index was also very high at 2435.

<sup>23</sup> Protected during the past 18 or 20 years



### 3.2.2 Non-GM seed breeders and availability of non-GM seeds

The concentration of the seed industry certainly had an impact on the development of non-GM varieties. Some firms who were releasing non-GM seeds some years ago (e.g. Asgrow, First Line, NK or Garst) now belong to groups (e.g. Monsanto and Syngenta) that no longer operate this business in the U.S.

As the number of firms breeding and releasing non-GM soybean has decreased, the diversity of varieties has also decreased. Nevertheless, it seems that diversity still exists for U.S. farmers willing to grow non-GM soybeans. It is true that there are many more transgenic than non-GM varieties available on the market, and therefore there is more diversity in the GM market. Still, we could list 162 different non-GM private or public soybean varieties available in the 2009 or 2010 seasons (see Table 3). All State Universities breed and release non-GM varieties. In addition, while Syngenta U.S. and Monsanto have withdrawn from the non-GM market, Pioneer and Stine still conduct non-GM breeding, as do several small companies. The data presented in Table 3 are not exhaustive, because small breeding companies were surely overlooked and also because information on the activities of Mertec LLC and Soygenetics, two medium-sized soybean breeding companies that may also breed non-GM varieties, was not available.

| <b>Firms/Universities</b>                                      | <b>Type of soybean varieties bred (GM or non-GM)</b> | <b>Number of GM varieties in the last line-up</b> | <b>Number of Non-GM varieties in the last line-up</b> |
|--|--|---|---|
| <b>North-Dakota State University</b>                           | Only non-GM  |   | 7   |
| <b>Minnesota State University</b>                              | Both   |   | 13  |
| <b>South-Dakota State University</b>                           | Both   |   | 3   |
| <b>Iowa State University</b>                                   | Both   |   | 34  |
| <b>Ohio State University</b>                                   | Only non-GM  |   | 10  |
| <b>Missouri State University</b>                               | Both   |   | 3   |
| <b>Arkansas State University</b>                               | Only non-GM  |   | 3   |
| <b>Kansas State University</b>                                 | Both   |   | 5   |
| <b>Pioneer</b>   | Both   |   | 8   |
| <b>Stine</b>   | Both   | 118   | 20  |
| <b>Hornbeck - Soytech</b>                                      | Both   | 41  | 7   |
| <b>NuTech Seeds</b>  | Both   | 55  | 5   |
| <b>Galena Genetics</b>   | Only non-GM  | 0   | 5   |
| <b>EMerge Genetics</b>   | Only non-GM  | 0   | 25  |
| <b>Dairyland (Dow)</b>   | Both   | 38  | 2   |
| <b>Syngenta Canada</b>   | Both   | 20  | 12  |
| <b>Syngenta U.S. (Garst, Golden Harvest, NK)</b>               | Only GM  | 80  | -   |
| <b>Monsanto (Asgrow, Dekalb, Delta &amp; Pine, First Line)</b> | Only GM  | 52  | -   |
| <b>Mycogen (Dow)</b>   | Only GM  | 44  | -   |

**Table 3– Availability of non-GM seeds in the U.S. (Data from companies’ websites and personal communications, 2009)**

We now describe the non-GM breeders in more detail, including some characteristics of their non-GM varieties. We begin with public breeding in State Universities.

### 3.2.2.1 *State universities*

Breeding programs in State Universities have three primary objectives:

- 1) developing new cultivars,
- 2) developing improved germplasm lines
- 3) performing basic research on plant breeding (Sleper and Shannon, 2003).

Through these activities, and particularly through the development of new cultivars, State Universities have become a central player in non-GM soybean breeding in the U.S.

According to James Orf, Professor of agronomy and plant genetics in the State University of Minnesota, ‘much of the breeding work for non-GMO varieties is now done at state universities’.<sup>24</sup> Shannon Grover, his counterpart at the university of Missouri, confirms that without ‘public programs, there would be little choice for farmers’.<sup>25</sup>

#### 3.2.2.1.1 Why breed non-GM soybeans?

All universities studied have a non-GM breeding program, and this seems to be the case for all U.S. State Universities. According to William Schapaugh, Professor of soybean breeding and genetics at Kansas State University, ‘the major public soybean breeding programs have a significant portion, or all of their resources devoted to the improvement of conventional germplasm.’<sup>26</sup> Though most universities breed GM and non-GM soybeans, there are some that breed only non-GM varieties. Steve St Martin, who led the soybean breeding program at Ohio State University between 1991 and 2008, ‘initially attempted to incorporate Monsanto’s gene for glyphosate resistance’, but abandoned it because he ‘could never get high-yielding varieties with it’. There are also specific rationales for breeding non-GM varieties: to provide varieties to producers of this niche market, and to build improved germplasm that is easy to transfer to other breeders.

Rather than compete with Monsanto and other big seed companies, and duplicate their efforts on GM breeding, Ted Helms feels that his research efforts are better spent on non-GM breeding: ‘the development and release of conventional cultivars provides farmers with an alternative to buying GMO cultivars from private companies’.<sup>27</sup>

Universities may therefore consider non-GM breeding of varieties for general use or Identity Preserved production for human use, as ‘a niche that is not being pursued by the private sector’.<sup>28</sup> Along with providing varieties to farmers, another research duty of State Universities is to enhance germplasm resources for plant breeders. As mentioned by James Orf, ‘the breeding of non-GM varieties makes the material available to anyone without restrictions where GM varieties require the permission of the company owning the GMO trait in order for there to be transfer of material’.<sup>29</sup>

#### 3.2.2.1.2 Characteristics and performances of non-GM varieties released

The non-GM varieties released by the State Universities studied, show a relatively global diversity in their characteristics. This does not necessarily mean that they cover all farmers’ needs in all areas considered. A more complete assessment of the varieties and their characteristics would have

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<sup>24</sup> The Organic and Non-GMO Report, July 2008

<sup>25</sup> Conventional soybeans draw interest, Apr 3, 2009, By David Bennett, Farm Press Editorial Staff.

<sup>26</sup> Personal communication, 30<sup>th</sup> of July 2009.

<sup>27</sup> Ted Helms (Professor of Soybean Breeding and Genetics at North Dakota State University), Hatch Project 2008.

<sup>28</sup> James Orf, Professor of agronomy and plant genetics at University of Minnesota, personal communication the 19<sup>th</sup> of August 2009.

<sup>29</sup> James Orf, personal communication the 19<sup>st</sup> of August 2009.

to be implemented, in relation to the local farming contexts and farmers' demand. The data collected does, however, give a good first overview of the situation.

The maturity groups of the varieties released by universities range from 00 to V, which completely covers the geographic area considered in the study. According to Grover Shannon, however, there is a shortage of Group 4 non-GM varieties.<sup>30</sup>

These varieties seem to be competitive compared to private ones. Several breeders interviewed consider that non-GM varieties yield like private Roundup Ready varieties. However, some universities are now shifting their breeding programs to the development of varieties for specialty crops in Identity Preserved markets, such as food types.

### 3.2.2.2 Characteristics of non-GM varieties

Some private companies are still breeding non-GMO soybeans, including market leaders such as Pioneer, Stine or Syngenta, as well as some smaller companies that specialize in germplasm research, in particular locations, or in IP soybean for human food use.

One hundred sixty two (162) non-GM varieties have been listed from the above breeders, of which 85 (52%) have been developed by private breeders and 77 (48%) by public breeders. 64% of the varieties have been developed for general use and 36% for special use. The data confirms the lack of group IV non-GM varieties, as only 3 are available (see Table 4).

| <b>Maturity groups / Type of use<br/>(number of varieties)</b> | <b>General use</b> | <b>Special use</b> | <b>Total</b> | <b>Total (%)</b> |
|--|--------------------|--------------------|--------------|------------------|
| <b>00</b>  | 10                 | 5                  | 15           | 9.32%            |
| <b>0</b>   | 19                 | 11                 | 30           | 18.63%           |
| <b>I</b>   | 21                 | 26                 | 47           | 29.19%           |
| <b>II</b>  | 23                 | 7                  | 30           | 18.63%           |
| <b>III</b>   | 15                 | 6                  | 21           | 13.66%           |
| <b>IV</b>  | 3                  |                    | 3            | 1.86%            |
| <b>V</b>   | 12                 | 2                  | 14           | 8.70%            |
| <b>Total</b>   | 103                | 57                 | 160          | 100%             |

**Table 4: Maturity groups and type of use of non-GM, number of varieties and % (Data from companies' websites and personal communications, 2009)**

Yield performance depends on how well varieties are adapted to the particular characteristics of the fields and areas of growth, which cannot be assessed at a general level. Varieties can only be compared on a local basis, through field trials conducted by state universities.

According to the private and public breeders interviewed, the yields of existing non-GM varieties are similar to or higher than Roundup Ready varieties, excluding some special-trait soybeans with lower yields (e.g. those with high protein level).

<sup>30</sup> Conventional soybeans draw interest, Apr 3, 2009, By David Bennett, Farm Press Editorial Staff

### 3.3 Brazil

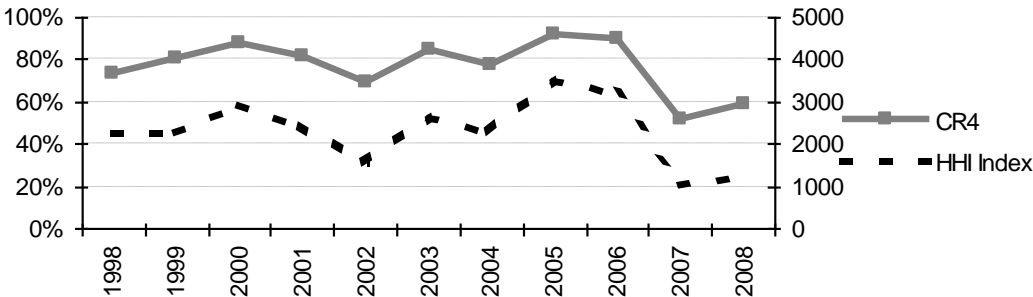
This section describes the Brazilian seed industry and the availability of new non-GM seeds for Brazilian farmers. In light of the difficulty obtaining commercial data for this sector, we use data from the National Cultivar Registry (RNC) between 1998 and 2008.

#### 3.3.1 Brazilian soybean industry

Before the approval of the Cultivar Protection Law in April 1997, cultivars were the property of the public domain and their different uses were free. The registration of cultivars to the RNC (the source of our data) therefore began in 1998. In 2008 no less than 29 companies had registered at least one variety.

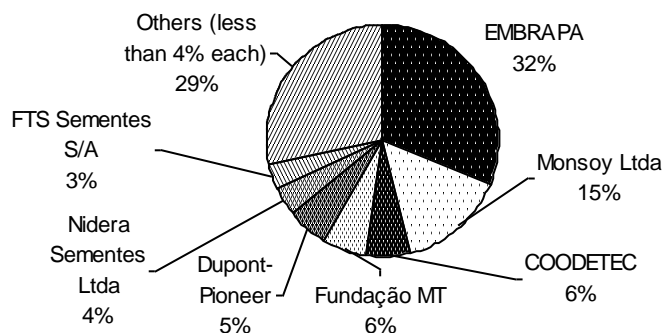
The new law on IPR created incentives for multinationals like Monsanto (Monsoy), Pioneer, or Nidera to acquire Brazilian firms. Nevertheless, the number of firms registering new cultivars remained quite stable over the years, ranging from a low of six in 2003 to a high of 15 in 1998 and 2007 (9.6 on average).

The structure of the sector, measured using these variety registrations, show a high level of concentration that tended to decrease in recent years. The HHI index (see Figure 10) was over 1800 points eight years out of the nine between 1998 and 2006. It fell to 1053 and 1242 points in 2007 and 2008. This variation in the HHI index is confirmed by the CR4. The “market share” of the four leading companies ranged from 68% in 1998 to 91% in 2006. It fell to almost 51% in 2007 and 59 % in 2008, though this situation could be temporary. This trend will need to be confirmed in coming years, because these numbers can be explain by two possible, special circumstances. The first is that there was a high number of firms registering varieties in 2007 (15 in 2007, versus eight in 2006 and 12 in 2008). In addition, Embrapa registered very few varieties in 2008.



**Figure 10 : Concentration in the Brazilian soybean seed industry. CR4 and HHI on variety registration activity (Data from RNC Brazil, 2009)**

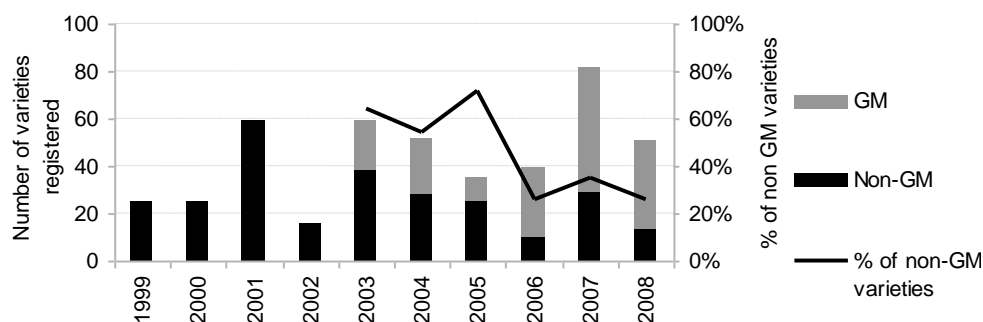
Embrapa is the public company that leads the Brazilian seed industry. It registered 32% of the 629 soybean varieties registered between 1998 and 2008. Embrapa therefore owns one third of the protected Brazilian soybean germplasm resources (see Figure 11). Monsoy is the largest private company in Brazil, and owns 14% of the varieties. The third and fourth largest companies are Brazilian: Coodetex and Fundação MT.



**Figure 11: Percentage share of soybean varieties registered between 1998 and 2008 in Brazil (Data from RNC Brazil, 2009)**

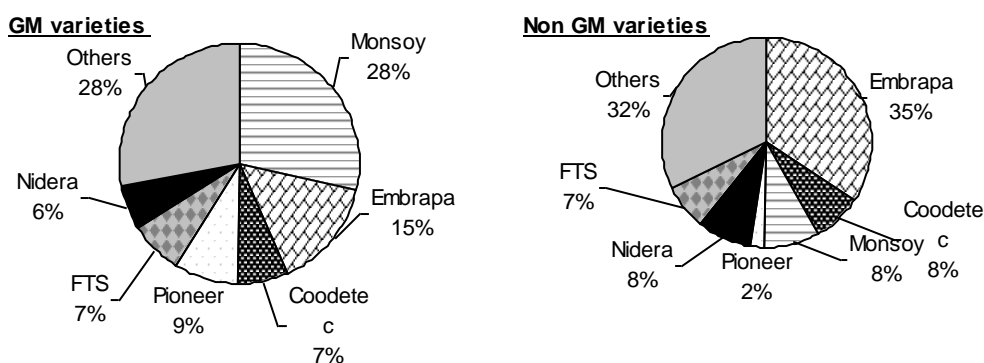
### 3.3.2 Availability of non-GM seeds

Regulatory approval of GM soy occurred in 2003 when 21 GM varieties were registered in the RNC. This number increased to 53 in 2007 and 38 in 2008. During the same period, the number of registered non-GM varieties decreased slightly, and their share of the total number of varieties fell from 64% in 2003 to 25% in 2008 (see Figure 12).



**Figure 12: Number of GM and non GM varieties registered in Brazil between 1999 and 2009 (Data from RNC Brazil, 2009)<sup>31</sup>**

Globally, from 2003 to 2008, 143 non-GM varieties (45% of the total) and 175 GM varieties have been registered. As shown on Figures 13 and 14, as multinational companies stopped registering non-GM varieties (in 2004 for Monsoy and 2005 for Pioneer) most are now produced by Brazilian companies like Embrapa, who registered 35% of the non-GM varieties and only 15% of GM varieties between 2003 and 2008.



<sup>31</sup> 180 non-GM varieties had also been registered in 1998, the first year of registration.

**Figure 13 and Figure 14 : Registration of GM and non GM varieties between 2003 and 2008, by firms (Data from RNC Brazil, 2009)**

New non-GM varieties are therefore still available for Brazilian farmers, though their relative share is decreasing. The activity of local companies, and particularly Embrapa, has guaranteed the existence of such varieties in recent years.

### **3.4 Extinction of non-GM soybean seed releases in Argentina**

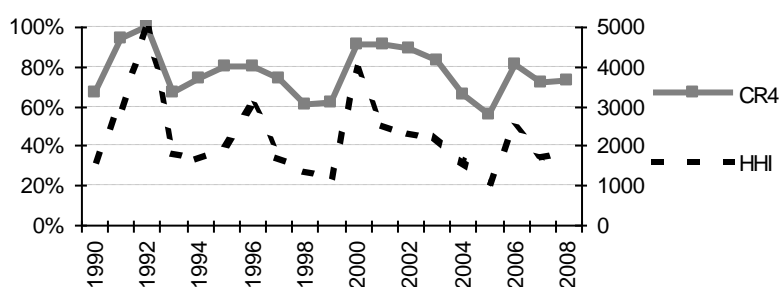
Based on the official quantities of soybean seed sales and the actual area planted with soybeans, 21.4% of the soybean seeds used by Argentinean farmers in 2004 have been legally purchased (Rapela, 2006). The remaining were illegal seeds (called ‘bolsa blanca’) or seeds saved from the past harvest. Therefore, it is not possible to find reliable data on the soybean seed market in Argentina.

All marketed varieties must, however, be registered in the National Register of Cultivars with a description of their different characteristics, including transgenic events. These data are used here to provide some information on seed market concentration and transgenic characteristics of authorized varieties. They provide a trend on how the commercial availability of new non-GM seeds has evolved. The results are quite clear: the last non-GM seeds in Argentina were registered in 2005.

#### **3.4.1 Argentinean soybean seed breeding industry**

Since 1990, 45 companies have registered at least one soybean variety to the National Register of Cultivars. There was a low of two registering in 1992 and a high of 12 in 2004, but the average number of companies registering at least one variety per year increased from 7.3 in the 1990s to nine after 2000.

With regard to market structure (measured using variety registrations), market concentration fluctuates widely but often reaches high levels (see Figure 15). The four leaders in plant variety registration represented, between 1990 and 2008, from 55% to 100% of the total number of registrations. This variation in the CR4 is confirmed by the HHI which ranges from 1082 points (in 2005), to 5000 (in 1992). Over the last 18 years, the HHI has been above 1800 points 11 times (which is the level for considering a market concentrated).



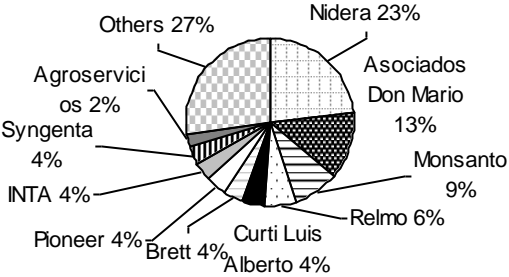
**Figure 15: Concentration in the Argentinean soybean seed industry. CR4 and HHI on plant registration activity (Data from RNC Argentina, 2009)**

Seed industry world leaders are not leading Argentinean soybean market. Monsanto, which was once one of the top four soybean seed sellers in Argentina, suspended its sales, research, and development of soybean seeds in this country in 2004 because of the black market. For the same reason, Pioneer is reluctant to invest locally, and had no soybean breeding program in Argentina in 2003.

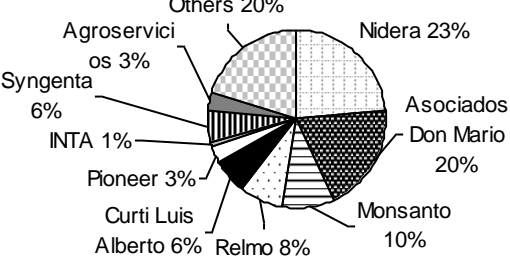
The largest firm in terms of varieties registered per year in the National Register of Cultivars is Nidera Semillas S.A. This company is an independent division of Nidera, a multinational corporation originating from Holland. Nidera Semillas was created in Argentina in 1988 with the acquisition of facilities and licences of Asgrow Argentina. The firm now markets Roundup Ready soybean seeds under a licence with Monsanto (Rapela, 2006).

The two other leaders over the last 10 and 20 years are the Argentinean based companies Asociados Don Mario and Relmo S.A.

**Varieties registered since 1990**



**Varieties registered since 2000**

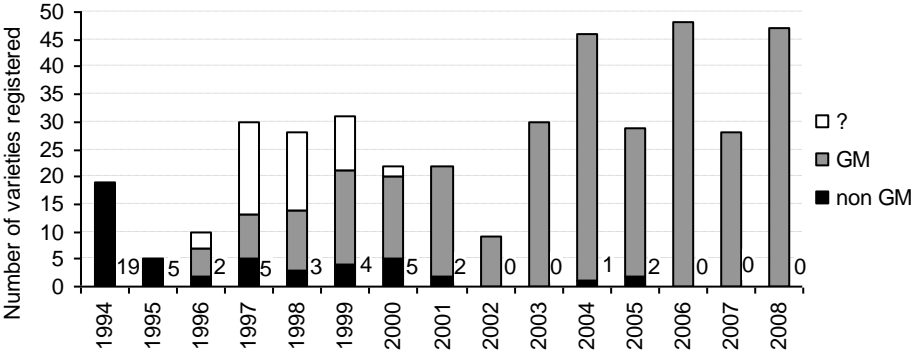


**Figure 16 and Figure 17: Percentage share of soybean varieties registered between 1990 and 2008 and between 2000 and 2008 (Data from RNC Argentina, 2009)**

As can be seen in Figures 16 and 17, soybean breeding activities in Argentina are mainly carried out by the private sector, and this trend has been reinforced in the last decade. After having registered varieties almost every year in the 1990s, the INTA (National Institute for Agricultural Technology), the main public research actor in agriculture in Argentina, registered only two varieties (both non-GM) between 2000 and 2008.

**3.4.2 Availability of non-GM seeds**

Due to the development of GM soybeans, breeding companies have virtually stopped releasing non-GM soybeans. The National Register of Cultivars (see Figure 18) shows that the last non-GM soybean varieties were registered for general use in 2005, by the INTA.



**Figure 18: Number of GM and non-GM varieties for general use protected per year in Argentina (Data from RNC Argentina, 2009)<sup>32</sup>**

Four varieties are also registered in the category ‘soybean for human consumption’, all non-GM. The most recent one, called Kumen 4500, was registered in 2005. It is the last non-GM private

<sup>32</sup> For some of the oldest varieties, it has been impossible to find information on transgenic characteristics (varieties mentioned with “?”)

soybean variety released in Argentina. The variety was introduced from the U.S. by the company Areco Semillas, now a subsidiary of Don Mario.

Another seed producer, FERIA de Norte Semillas, also produces and markets food grade non-GM varieties. The varieties are also introduced from the U.S., from eMerge Genetics. Two varieties are in the process of being registered and four more will be released in the coming years. According to the owner of the company, they recently developed this supply of non-GM seeds because the demand for this kind of soybean is increasing in the Argentinean market but mostly from abroad.<sup>33</sup>

## **4 The Future of non-GM plant breeding**

Banks of germplasm resources (in which the global genetic heritage is stored) do exist for soybeans, in the U.S. and in other countries. However, these resources are not readily available for the development of high-performance varieties for production. The future availability of high-performing non-GM varieties depends on the existence of non-GM elite lines (i.e. varieties that integrate recent breeding efforts in terms of yield or resistance to disease).

This section attempts to outline potential availability of such non-GM elite lines in the near future, and their use by breeders, in the different countries considered. The demand for non-GM soybeans, the possibility of patenting plants, and the technical constraints created by new traits may have a decisive influence on the final availability of high-performing non-GM seeds.

Before detailing these possible futures in each country, we address the decisive technical issue of breeders' choice between backcross and forward breeding for transgenic event integration.

### **4.1 Forward breeding vs. backcross**

The future availability of competitive non-GM varieties depends on the existence of non-GM breeding programs that develop varieties with equivalent basic performance to GM varieties. In companies developing mainly GM varieties, the size of such non-GM breeding programs is subordinated to the breeding program's characteristics, and especially to the choice between forward breeding and backcross techniques to insert transgenic events.

According to Mumm (2007), 'backcross breeding involves repeated crossing with selection to an elite inbred, with the goal of recovering a derived line that essentially resembles this elite parent with the addition of one or a small number of favourable alleles from the non recurrent parent'. With this method, the transgenic trait is added at the end of the breeding process, into an elite non-GM inbred line. The basic breeding program is made on a non-GM basis, which means that non-GM varieties exist that are equivalent to GM varieties.

'Forward breeding refers to any system of inbred line development, irrespective of the number of loci involved or the balance of favourable alleles among the parents of the population, involving the creation of a source population followed by inbreeding with selection, with the goal of recovering an improved line for one or more traits (e.g., pedigree selection)' (Mumm, 2007). With this technique, the breeding program is conducted on a GM basis, which means that there is no non-GM equivalent output at the end of the process.

Private companies (and some public breeding programs) predominantly used forward breeding for the development of Roundup Ready soybean lines.<sup>34</sup> According to top executives of Monsanto, retracing the history of RoundupReady® soybeans, the trait for herbicide tolerance had first been

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<sup>33</sup> Personal communication with Eduardo Cucagna, owner of FERIA de Norte Semillas, 21<sup>st</sup> of September 2009.

<sup>34</sup> Personal communication with different public or private plant breeders.



widely inserted in elite varieties: ‘An extensive breeding and backcrossing program was initiated in 1991 between Monsanto and Asgrow researchers. Other soybean breeding companies were also included in this effort in order to ensure that the trait was broadly available to farmers. Crosses between susceptible and tolerant genotypes were made on a large scale. Line 40-3-2 was backcrossed three times or forward crossed to a wide range of genetic backgrounds over all maturity groups to ensure that the Roundup Ready trait would be available in a diverse set of genetic background. (...)

At least six breeding companies initially sold RR soybeans in 1996, with the majority of companies introducing RR soybeans in 1997. (...)

By 2000, most breeders used the RoundupReady® gene as a base trait in a high percentage of breeding populations. Forward breeding with the Roundup Ready trait on a large commercial breeding scale was relatively straightforward and inexpensive, and today the transgene is present in thousands of breeding crosses while maintaining historical rates of genetic gain.’(Crosbie et al., 2006)

Monsanto then abandoned the development of non-GM varieties as well as non-GM breeding. According to a Monsanto executive in Europe they indeed stopped their European soybean breeding programs, instead adapting American varieties to local conditions, because they no longer had non-GM elite varieties available in the U.S.<sup>35</sup>

Most other companies that developed RR soybean varieties through forward breeding and non-GM varieties had two separate breeding programs. The ‘main disadvantage of this system is that [they] have narrower genetic base to select new lines from non-GMO program’.<sup>36</sup> This could have led to lower performance for non-GM varieties, though this situation might have changed due to the introduction of new traits (ASA, 2008).

Monsanto’s entire breeding program is still based on GM product with RR2Y event, but many companies are now developing breeding programs in non-GM background to backcross the new traits into the elite lines. According to several public and private breeders, from Argentina and the U.S., this solution provides more flexibility and is ‘easier, faster and cheaper’.<sup>37</sup> One breeder from Argentina even says that the companies that kept a large percentage of their breeding programs on non-GM background are now in a better position for introducing new traits.<sup>38</sup> Though this statement may be true for companies that breed varieties with different traits (via licenses), it may not be the case for companies that develop, breed, and market only their own trait (like GAT for Pioneer). The development of several new biotech traits could paradoxically lead to better availability of resources in non-GM elite lines. This situation could, however, vary among countries, depending on the breeding industry structure and the type of companies operating.

## **4.2 USA: dependency on industry leaders**

Non-GM seeds are currently provided in the U.S. market by universities, a few small companies, and two or three industry leaders. However, a combination of the characteristics of the breeding industry, the increase in patents on varieties, and the changes in public breeding activities may lead to a drastically different situation in the future and the availability of non-GM competitive varieties may depend on the decisions of few industry leaders.

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<sup>35</sup> Personal communication with a Monsanto executive.

<sup>36</sup> Personal communication with a Pioneer executive.

<sup>37</sup> Personal communications with different public or private plant breeders.

<sup>38</sup> Personal communication.

## 4.2.1 Future of public research on soybean breeding

If present trends continue in the U.S. breeding sector, State universities may no longer be a competitive source of non-GM soybean varieties in the future. As mentioned by Sleper and Shannon (2003) ‘intellectual property protection, the ability to earn a good return on research investment, and reductions in public budgets have shifted the majority of the soybean breeding effort from the public to the private sector’. Universities will most likely become upstream partners of private companies who are in charge of germplasm development, basic research, and education of future breeders; a situation that has already begun to materialize. At the same time, universities will likely move away from near-market activities.

### 4.2.1.1 *Decrease in public financial resources*

In a context of a dramatic increase in private research investment over the past years and decades, public sector breeding research funding has declined (Heisey et al, 2001).<sup>39</sup> Breeding departments have therefore had to find partnership with private companies or farmer organizations (Coffman et al., 2003).

A plant breeder from a State University deplors this situation. In his opinion, ‘the future of public soybean breeding is in serious jeopardy.’ He argues that ‘the Agriculture Administration does not support his efforts either financially nor do they even support the concept of public soybean breeding’, and he therefore must rely on ‘farmers who do not understand the breeding process and do not understand the amount of funding required for a successful breeding effort.’<sup>40</sup> However, the situation is not quite so dire for all breeders. For example, Steve St Martin from Ohio, feels that ‘right now is a nice time to be in soybean breeding’ and that ‘there has been no other time in [his] career that [their] breeding program has gotten so much attention and support’.<sup>41</sup> His program, ‘part of Ohio State’s Ohio Agricultural Research and Development Center (OARDC), has expanded its personnel and technology over the past four years. (...) Through grant support from the Ohio Soybean Council and funding and marketing opportunities through (...) an organization that links university resources with industry.’<sup>42</sup>

If some Universities can develop their breeding activities through private funds, one of the main consequences may be that the needs and interests of these new partners drive germplasm and breeding programs, hindering the development of new (non-GM) competitive varieties from universities.

### 4.2.1.2 *Decrease in access to germplasm resources*

With the decline in public financial resources, public breeders will also face a drop in germplasm resources available for their activity, due to the development of patents on soybean cultivars (see above). As noted by Sleper and Shannon (2003): ‘because of intellectual property rights, private companies [indeed] rarely share germplasm for crossing’.

In the universities studied, only one plant breeder said that he was using both private and public germplasm for his activity. All the others rarely or never use private resources with material transfer agreements.

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<sup>39</sup> With regard to funding sources of U.S. public agricultural research, see also Schimmelpfennig and Heisey (2009)

<sup>40</sup> Personal communication.

<sup>41</sup> Soybean Breeding Program Growing to Meet Industry Demands, 06/05/2007, Candace Pollock, Ohio State University Extension (<http://extension.osu.edu/~news/story.php?id=4130>)

<sup>42</sup> Ibid

This restriction of free germplasm exchange and utilization through the development of patents therefore impedes the relative competitiveness of State universities, with respect to private companies that have patented their varieties.

#### **4.2.1.3 *Future global competitiveness of public breeding***

Though public non-GM varieties released in recent years have been competitive against private RR varieties in terms of yields (see above), and provide an alternative solution for farmers willing to grow non-GM soybeans, this may not continue to be the case in coming years.

It would be difficult, if not impossible, for public soybean breeding programs to stay competitive with limited financial and germplasm resources, while companies like Pioneer and Monsanto release new varieties based on large germplasm resources and costly technology.

James Orf, from the State University of Minnesota, emphasizes the diversity of their tasks, compared to private breeders: ‘the private programs are much larger than public programs (on the order of 5-10 times larger) and the only thing private breeders do is select for commercial varieties while public breeders do a lot of work with graduate students on genetic studies, exotic germplasm incorporation and disease resistance breeding as well as teach classes so it is much harder to make as much breeding progress as private breeders. (...) We just do not have the resources (and time) that the large companies have’. Steve St Martin also anticipates the future of plant breeding, noting that due to the size and costs of these private programs it ‘will be more difficult for universities to develop a finished product, i.e., a variety that has all the traits that growers demand. But public breeders can supply a component, through release of germplasm, and then it will be up to the companies to put it all together.’

#### **4.2.1.4 *Focus on germplasm improvement***

As Sleper and Shannon (2003) note, ‘the public sector soybean breeders conduct [already] most of the research in the area of germplasm enhancement’. Public breeding is likely to focus on this activity in the future, as it is not very competitive in the development of new cultivars and is dependent on private funds. This trend is already evident in some universities, such as Kansas State University, where they are ‘placing less emphasis on developing varieties that would be directly used by farmers, and placing more emphasis on developing varieties and germplasm that would be useful to private breeders to enhance crop performance.’<sup>43</sup> The Agricultural Research Service of the USDA also made this move in the late 1990s (Coffman et al., 2003). All of this means a change in the organization of the global U.S. breeding system, where public breeders would no longer compete with private companies in the creation of new varieties, but instead would serve as upstream research partners for these companies, developing and licensing improved germplasm with specialized traits.

The public sector may also continue with a number of other activities:

- developing varieties for Identity Preserved markets that are not of interest to private companies,
- continuing with basic research and methodology development,
- continuing to provide education and training for people that are employed by the private sector (Heisey et al., 2001).

## **4.2.2 Competitive challenges facing small breeders:**

Small companies that breed non-GM soybeans may face a number of difficulties in the coming years. Because of high Research and Development expenditures and regulatory costs, the seed

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<sup>43</sup> Personal communication with William Schapaugh, Professor of soybean breeding and genetics at Kansas State University, the 12<sup>th</sup> of August 2009.

industry is characterized by strong economies of scale and scope that result in incentives for industry concentration. This means that ‘those that do not get large are vulnerable to being driven out of the market by larger and more cost efficient firms.’ (Fulton & Giannakas, 2001) The existing trends (IPR reinforcement and costly technologies) may reinforce this process (Sleper and Shannon, 2003). Also, small companies compete with industry leaders but rely on their technology (e.g. transgenic traits) and are vulnerable to the willingness of large companies to supply this technology.

The development of plant patenting by industry leaders creates another dramatic challenge for small companies by making their access to recent germplasm resources costly and uncertain (Graff et al., 2004). Under the former system of plant protection using PVP certificates, small companies could integrate industry leaders’ research efforts into their breeding efforts, and could therefore compete in basic breeding activities. Without this access they are forced to use their own germplasm and public resources, competing with firms owning considerable germplasm and variety resources. Even if small companies were to successfully negotiate business agreements to access these technological and germplasm resources, the future of small companies appears to be in jeopardy, unless they are able to find niche markets (e.g. for special traits).

Like universities, small companies may therefore not continue to be a source of competitive non-GM varieties for general use. Farmers may have to rely exclusively on industry leaders to get such varieties.

**4.2.3 Which strategy for industry leaders?**

Given the concentration of patents on elite varieties, three to five companies will determine the immediate future of non-GM soybean breeding, and therefore the existence of competitive, phenotypically-diverse, non-GM soybean varieties in the U.S. If Pioneer, Stine, and Syngenta Canada also decide to stop releasing non-GM varieties, the availability of competitive non-GM varieties for general use may soon be in serious jeopardy. Moreover, if universities and small companies exit this market, large companies will have to expand their line-up of non-GM varieties to guarantee good phenotypic diversity. In 2009, Pioneer, Syngenta Canada and Stine were supplying 36 different varieties (see Table 5), with no group 00 varieties and only 2 group 0 varieties. Without an expansion of their non-GM line-up, the non-GM choices available to farmers may be limited or non-existent.

| Number of varieties    | Maturity groups |          |          |           |          |          | Total     |
|------------------------|-----------------|----------|----------|-----------|----------|----------|-----------|
|                        | 0               | I        | II       | III       | IV       | V        |           |
| <b>Pioneer</b>         |                 | 1        | 2        | 4         | 1        |          | <b>8</b>  |
| <b>Stine</b>           |                 | 1        | 5        | 7         | 5        | 2        | <b>20</b> |
| <b>Syngenta Canada</b> | 2               | 4        | 2        |           |          |          | <b>8</b>  |
| <b>Total</b>           | <b>2</b>        | <b>6</b> | <b>9</b> | <b>11</b> | <b>6</b> | <b>2</b> | <b>36</b> |

**Table 5: Supply of non-GM varieties for general use in 2009 by industry leaders (Data from 2009 line-up of companies)**

The availability of non-GM soybean seeds in the future will therefore depend on the ability and the will of the industry leaders to develop this type of variety. Large companies will first need to develop large non-GM breeding programs. As seen above (section 4.1), the appearance of new traits may lead to the development of backcross rather than forward breeding. This solution would offer more flexibility for companies like Stine, who breed varieties with different traits. As breeding would be done in a non-GM background under these circumstances, non-GM elite lines would be available. However, companies like Pioneer who develop their own traits (like Optimum GAT), may have more interest in a focussed breeding program dedicated to this new trait (such as Monsanto for RR and for

RR2Y traits). This might therefore mean a separate breeding program for non-GM varieties, if they also want to develop these varieties. If this were the case, the resources used for non-GM breeding will be inferior to the ones used for GM breeding, and non-GM varieties may be less competitive over time.

The breeding system chosen by the leading companies will have important consequences on their ability to provide good non-GM varieties. Their production and marketing strategy, particularly concerning the new traits, will also play a decisive role in the availability and diversity of non-GM varieties. To date, the large companies were marketing transgenic soybeans that included Monsanto's RR trait, but unlike Monsanto did not appear have any particular strategic interest in marketing only this kind of soybean. It will be important to watch whether this situation changes as companies like Pioneer or Syngenta market new events.

Finally, the large firms' non-GM seed production and marketing may be driven by non-GM demand. Demand for non-GM seeds exists today, based on consumer (and animal producer) demand for non-GM soybeans and on the relative decrease in competitiveness of Roundup Ready soybeans. A decrease in this demand may reduce these companies interest in releasing non-GM varieties, and lead to a decrease in their supply. Conversely, sustainable demand for non-GM soybeans would probably result in a significant, ongoing supply.

### ***4.3 The central position of EMBRAPA in Brazil***

As Martinelli (2006) has shown, Embrapa is the key Brazilian institution involved in the formulation of technological arrangements in the seed industry. It is responsible for synergies and spillovers with regard to local agents, thus limiting the power of multinational corporations within the Brazilian seed market. Corroborating this information, Fuck et al. (2008) states: 'EMBRAPA began establishing partnerships with multinational corporations and grower's foundations with the aim of developing new varieties as well as assuring its leadership of the seed market. It is no exaggeration to say that Embrapa's partnership approach has been fundamental to the development of germplasm adapted to tropical conditions, enabling soy to be grown in various regions of Brazil'.

The existence of non-GM soybean germplasm and elite lines in Brazil also depends on the activity of the public company. Between 2003 and 2008 Embrapa has continued to breed and release non-GM varieties and thus has partially compensated for the withdrawal of multinational companies from this activity. During this period, 65% of the varieties registered to the RNC by Embrapa were non-GM. If Embrapa continues with this research and production strategy, non-GM breeding and seed availability will certainly be guaranteed in Brazil in the coming years.

### ***4.4 Argentina: no high-performing non-GM seeds on a large scale for years to come***

As almost all Argentinean soybeans have been GM for several years, the main seed producers have stopped producing and selling non-GM soybean seeds. According to Leonardo Milanesi, a soybean breeder from the company Asociación Cooperativas Argentinas: 'in general terms, the largest soybean breeding enterprises have not kept breeding programs for non-GM varieties.'<sup>44</sup> Based on SAGPyA (the Argentinean ministry of agriculture) and the Food and Agriculture Organization (FAO) reports, this was already the case in 2004. This report also noted that two seed industry leaders maintain 'minimum programs' and concluded that 'improvements on non-GM lines are at least three

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<sup>44</sup> Personal communication the 22<sup>nd</sup> of August 2009.

years behind and at least two years are necessary to achieve a consistent production of commercial seeds. As a conclusion, it would need at least five years to get a variety with substantial performances and produced in quantities covering a low level of demand.’ (SAGPyA/FAO, 2004). Not all private plant breeders, however, accept this conclusion.

As noted in the SAGPyA/FAO report, some industry leaders retain non-GM breeding programs. This was confirmed in our investigations. They were at least two firms in 2009: Asociados Don Mario and another company<sup>45</sup> that dedicate 30% and less than 5% of their soybean breeding program to non-GM breeding, respectively. A smaller company, Asociacion Cooperativas Argentinas, also retains a small program.

Companies maintain these non-GM breeding programs partly because of occasional sales’ opportunities (through direct sales to growers, without registration). The primary reason, however, is to maintain non-GM lines, which are more flexible for integration of new transgenic traits. According to a breeder of a large company, ‘these last years, the interest for non-GM germplasm has increased internationally, because it is easier, faster and cheaper to integrate new traits (RR2Y, GAT or others) in non-GM background than in RR background.’<sup>46</sup> In his opinion, ‘companies which have kept a significant non-GM breeding program are now in a good position for the integration of new traits.’ These programs aim to improve germplasm resources rather than develop new varieties. According to Leonardo Milanesi, ‘for the research on non-GM soybeans, there is no off-season development to increase the number of generations, comparative field trials on yield performance are not done, or only in one location, when field trials for GMO varieties are done in at least 15 locations. It reduces the yield improvements for non-GM varieties compared to GM ones.’<sup>47</sup> Another breeder from a large company confirms that few resources are generally dedicated to these programs and that ‘the genetic gains for non-GM varieties have been low these last years.’<sup>48</sup>

The breeding engineer from Asociacion Cooperativas Argentinas validates the conclusion of the SAGPyA and FAO report. He adds, ‘if the market was changing in favour of non-GM varieties (what I do not believe), at least three years would be necessary to release non-GM seeds. You indeed need two years of field trials for registration, in at least three locations, and during this period you would be able to multiply some of the most promising materials.’<sup>49</sup>

The company Asociacion Don Mario could be ready to rapidly release competitive non-GM varieties. According to its Research Director, Marcos Quiroga: ‘it’s sure that we do not have important volumes of non-GM seeds and that we would need a couple of years to produce substantial volumes, but the varieties of our company are not behind GM seeds in term of yield performances.’<sup>50</sup>

In conclusion, with the exception of one industry leader, non-GM breeding programs in Argentina are confidential and dedicated to germplasm enhancement. They may, however, expand in the near future as a result of the development of varieties with new traits. At the moment, however, it would take most seed companies several years to release competitive non-GM seeds.

Public breeding at INTA is not focused on variety development (Fuck et al., 2008), therefore these private breeding programs may be the only source of non-GM varieties. Some varieties could also be imported from the U.S., as is already done for food-grade varieties.

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<sup>45</sup> This company asked for confidentiality.

<sup>46</sup> Personal communication.

<sup>47</sup> Personal communication the 1<sup>st</sup> of October 2009.

<sup>48</sup> Personal communication.

<sup>49</sup> Personal communication with Leonardo Milanesi, the 1<sup>st</sup> of October 2009.

<sup>50</sup> Personal communication with Marcos Quiroga (Research Director of Asociados Don Mario SA) the 1<sup>st</sup> of October 2009.

## 5 Conclusion

The first objective of this study was to assess the current availability of non-GM seeds in the U.S., Brazil, and Argentina. The information gathered in this report outlines the situation:

- In the USA, some farmers had difficulties acquiring non-GM soybean seeds in 2009. However, this was probably a short term problem caused by an unpredicted increase in the demand for these seeds on the part of seed producers and sellers, with non-GM soybeans up to approximately 9% of soybean plantings. The shortage is expected to be resolved next year via increased non-GM seed production. There is quite a bit of diversity on the U.S. market, with at least 162 non-GM public or private varieties currently available to farmers.
- In Brazil, around 45% of soybeans produced in 2009 were non-GM, and the public enterprise EMBRAPA guarantees the availability of non-GM seeds.
- In Argentina, where almost all soybean production is genetically modified, no new non-GM seeds have been registered since 2005. There are a few non-GM producers, but they are using old varieties.

The second objective of the study was to identify the main drivers that shape non-GM breeding activity and determine the future availability of non-GM seeds. We identified several factors that interact on this issue:

- The level of demand for non-GM soybeans, and therefore for non-GM soybean seeds, creates incentives to private producers to develop such varieties. In Argentina, where almost all producers grow GM soybeans, local seed breeders that dominate the seed market see no need to release non-GM seeds. On the contrary, in Brazil, the European demand for non-GM soybeans provides good market opportunities for non-GM growers and seed producers. In the U.S., Japanese demand for non-GM soybeans for food uses results in high premiums paid to farmers. This demand also stimulates the activity of small companies developing non-GM varieties and controlling the whole supply chain from seed breeding to exports. Similarly, leading breeders in the U.S. still develop non-GM soybeans and claim that they will develop such varieties as long as demand exists, although this may not necessarily be the case if this demand becomes very low.
- The public sector has a strong influence on the availability of non-GM seeds. Without the breeding activities of State universities, the availability of such seeds would be limited in the U.S. and the predicted decrease of these breeding programs may seriously compromise future availability of new competitive non-GM varieties for farmers. In Argentina, the last new non-GM varieties for general use were registered in 2005 by INTA, and this public institution no longer focuses its activities on soybean breeding. This scenario demonstrates that when demand is low, public sector programs are necessary to guarantee farmers' choice between GM and non-GM seeds. In a very different context, the activity of the public company EMBRAPA in Brazil still guarantees good availability of non-GM varieties.
- The legal framework on intellectual property rights for seeds, and particularly the right to patent new varieties, has significant consequences on global breeding activities and may result in the development of less competitive non-GM varieties. Because seed companies may find it difficult or impossible to access patented varieties developed by other firms, in the near future they may be forced to develop varieties relying only on their own (and on the public) germplasm resources. Patents may therefore lead to the exclusion of companies with smaller germplasm resources, and subject the availability of competitive non-GM varieties to the ability and will of industry leaders to breed and release them.

- More generally, mergers and acquisitions may reduce the number of firms breeding non-GM soybeans by decreasing the number of firms breeding soybean of any variety.
- Lastly, the techniques used by breeders to integrate GM traits in their varieties significantly influence the existence of non-GM elite lines that, if released, compete with GM varieties. The development of RR varieties, mainly done through forward breeding, has hindered the development of non-GM programs so far. However, the release of new genetic traits (like RR2Y or GAT) may change this situation. It is more flexible for firms developing different types of varieties, with different traits, to develop their new varieties in a non-GM background. Nevertheless, the companies that will release their own new genetic traits may chose, as Monsanto did in the 1990s, to develop all of their varieties in a GM background and abandon non-GM breeding.

Further investigations would be needed at the firm scale to clarify the different incentives and strategies generated by the emergence of these new genetic events and their consequences on a firm's choice of whether to breed and release non-GM varieties.

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## References

- Abrange. Available on (access on: 6 July 2009): <http://www.abrange.org/>.
- Alliprandini L. F., Abatti C., Bertagnolli P. F., Cavassim J. E., Gabe H. L., Kurek A., Matsumoto M. N., de Oliveira M. A. R., Pitol C., Prado L. C. and Steckling C. 2009. *Understanding Soybean Maturity Groups in Brazil: Environment, Cultivar Classification, and Stability*, *Crop Sci.*, 49: 801-808.
- ArgenBio. Available on (access on: 8 July 2009): <http://www.argenbio.org/>.
- ASA (American Soybean Association). Available on (access on: 3 May 2009): <http://www.soystats.com/>.
- ASA (American Soybean Association). 2008. *Future protein supply for the EU: a U.S. soybean view*, In: *Producing For Tomorrow's Market*, Irish Poultry and Egg Conference, Monaghan, 4 November.
- Bonny S. 2009. *Issues, impacts, and prospects of the first transgenic crops tolerant to a herbicide. The case of glyphosate-tolerant soybean in the USA*, Contributed Paper prepared for presentation at the International Association of Agricultural Economists Conference, Beijing, China, August 16-22, 2009.
- Brennan M., Pray C., Naseem A., Oehmke J. F. 2005. *An Innovation Market Approach to Analyzing Impacts of Mergers and Acquisitions in the Plant Biotechnology Industry*, *AgBioForum*, 8(2&3): 89-99.
- CONAB (Compania Nacional de Abastecimento). Available on (access on: 3 June 2009): [www.conab.gov.br](http://www.conab.gov.br).
- Coffman W. R., Lesser W. H. and McCouch S.R., 2003, *Commercialization and the Scientific Research Process*, Conference, Cornell University, Ithaca, NY, May 20-21, 2003.
- Crosbie T., Eathington S., Edwards M., Reiter R., Stark S., Mohanty R., Oyervides M., Buehler R., Walker A., Dobert R., Delannay X., Pershing J., Hall M. and Lamkey K., 2006, *Plant Breeding: Past, Present, and Future*. In *Plant Breeding: The Arnel R. Hallauer International Symposium*, Iowa State University Press. Lamkey Kendall & Lee Michael (eds). 3-50.
- ETC group. 2005. *Global Seed Industry Concentration*. Communiqué - Issue 90.
- ETC group. 2008. *Who Owns Nature? Corporate Power and the Final Frontier in the Commodification of Life*. Communiqué - Issue 100.
- Fernandez-Cornejo J. 2004. *The seed industry in U.S. agriculture: An exploration of data and information on crop seed markets, regulation, industry structure, and research and development*. Agriculture Information Bulletin Number 786, January 2004. Resource Economics Division, Economic Research Service, U.S. Department of Agriculture.
- Fuck M. P., Salles-Filho S., de Carvalho S. P. and Bonacelli M. B. 2008. Intellectual property protection, plant breeding and seed markets: a comparative analysis of Brazil and Argentina. *Int. J. Tech. Manag. Sustain. Dev.*, 7 (3): 223-235.
- Fulton M. and Giannakas K. 2001. *Agricultural Biotechnology And Industry Structure*. *AgBioForum*, 4, 2, 137-151.

- Graff G. D., Wright B. D., Bennett A. B. and Zilberman D. 2004. Access to intellectual property is a major obstacle to developing transgenic horticultural crops. *California Agriculture*, 58 (2): 120-126.
- Heisey P. W., Srinivasan C. S. and Thirtle C. G.. 2001. Public Sector Plant Breeding sector in a privatizing world. USDA, ERS, *Agriculture Information Bulletin* No. (AIB772), August 2001.
- ISAAA (International Service for the Acquisition of Agri-biotech Applications). Available on (access on: 15 may 2009): <http://www.isaaa.org/>
- Kesan J.P., and Gallo A.A. 2005. Property rights and incentives to invest in seed varieties: Governmental regulations in Argentina. *AgBioForum*, 8(2&3): 118-126.
- Martinelli O. 2006. Relatório Setorial Final: setor sementes. Diretório de Pesquisa Privada (DPP), available on: [www.finep.gov.br/portaldpp/](http://www.finep.gov.br/portaldpp/) Accessed on: 30.July.2009.
- Milanesi J. 2008. Analyse des coûts induits sur les filières agricoles par les mises en culture d'organismes génétiquement modifiés – Etude sur le maïs, le soja et le poulet Label Rouge. Rapport de recherche du Centre de Recherche et d'Etude en Gestion, UPPA, 2008. [http://iae-creg.univ-pau.fr/live/digitalAssets/84/84781\\_Rapport-CREG-OGM.pdf](http://iae-creg.univ-pau.fr/live/digitalAssets/84/84781_Rapport-CREG-OGM.pdf)
- Milanesi J., Desquilbet M., Lucht E. and Rocha de Santos R. 2009. Current and future availability of non-genetically modified soybean seeds in the U.S., Brazil and Argentina. Co-Extra: GM and non-GM supply chains: their CO-EXistence and TRAcability (European re), Deliverable D3.11.3.
- Mumm R. H. 2007. Backcross versus Forward Breeding in the Development of Transgenic Maize Hybrids: Theory and Practice. *Crop Sci.*, 47 (3): 164-171.
- Nolan E. and Santos P. 2009. Evidence for increasing concentration in plant breeding industries in the United States and the European Union, Australian Agricultural and Resource Economics Society, Conference (53<sup>rd</sup>), February 11-13, 2009, Cairns, Australia.
- Pray C., Oehmke J.F. and Naseem A. 2005. Innovation and dynamic efficiency in plant biotechnology: An introduction to the researchable issues, *AgBioForum*, 8 (2&3): 52-63.
- PVPO (Plant Variety Protection Office). Available on (access on: 6 june 2009): <http://www.ams.usda.gov/AMSV1.0/PVPO>
- Reuters, 9<sup>th</sup> of March 2005, Safety Concerns Keep E.Asia Consumers Off GMO Food.
- RNC (Registro Nacional de Cultivares) Argentina. Available on (access on: 12 July 2009): [http://www.inase.gov.ar/index.php?option=com\\_content&view=article&id=107&Itemid=100&lang=es](http://www.inase.gov.ar/index.php?option=com_content&view=article&id=107&Itemid=100&lang=es)
- RNC (Registro Nacional de Cultivares) Brazil. Available on (access on: 10 august 2009): [http://extranet.agricultura.gov.br/php/proton/cultivarweb/cultivares\\_registradas.php](http://extranet.agricultura.gov.br/php/proton/cultivarweb/cultivares_registradas.php)
- Rapela, M. A.. 2006, Características de la propiedad varietal general y de la oferta de semilla de trigo y soja en Argentina. In Innovación y propiedad intelectual en mejoramiento vegetal y biotecnología agrícola : estudio interdisciplinar y propuestas para la Argentina, Rapela, Miguel Angel (Dir.), Schötz, Gustavo J. (eds.), Buenos Aires: Heliasta, 35-61.

- SAGPyA/FAO. 2004. Contexto y opciones para la exportación segregada de maíz y soja ovm y no ovm en condiciones de bioseguridad, conforme al protocolo de Cartagena, Proyecto FAO/SAGPYA TCP/ARG 2903.  
[http://www.sagpya.mecon.gov.ar/new/0-0/programas/fao\\_sagpya/Documento%203.pdf](http://www.sagpya.mecon.gov.ar/new/0-0/programas/fao_sagpya/Documento%203.pdf)
- Schimmelpfennig D. and Heisey P. 2009. U.S. Public Agricultural Research: Changes in Funding Sources and Shifts in Emphasis, 1980-2005. *Economic Information Bulletin* No. (EIB-45) March 2009.
- Schimmelpfennig, D., Pray C. E. and Brennan M. 2003. The Impact of Seed Industry Concentration on Innovation: A Study of U.S. Biotech Market Leaders. *Agr. Econ.*, 30: 157-167.
- SECEX/MDIC (Secretaria De Comércio Exterior/Ministério Do Desenvolvimento). Balança comercial brasileira. Available on (access on: 07 July 2009):  
<http://www.desenvolvimento.gov.br/sitio/interna/interna.php?area=5&menu=1161>
- Sleper, D.A. and Shannon, J.G. 2003. Role of public and private soybean breeding programs in the development of soybean varieties using biotechnology. *AgBioForum*, 6 (1&2): 27-32.
- The Organic & Non-GMO Report, July 2006. Japan's non-GMO soybean market update. Evergreen Publishing, Inc. Fairfield. USA.
- USDA. 2008. Agricultural Baseline Projections: Baseline Presentation, 2008-2017.  
<http://www.ers.usda.gov/briefing/Baseline/present2008.htm#crops>.
- USDA/FAS. United States Department of Agriculture / Foreign Agricultural Service. Available on (access on: 07 June 2009): <http://www.fas.usda.gov/>.
- USFD. 2007. Survey of legal regimes including international treaties. , Co-extra Program (www.coextra.eu): GM and non-GM supply chains: their CO-EXistence and TRAcability (European research project). Deliverable 7.1
- Vanloqueren G. and Baret P. V. 2009. How agricultural research systems shape a technological regime that develops genetic engineering but locks out agroecological innovations, *Res. Pol.*, 38 (6): 971-983.

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