Draft for comment

Not for citation

Science, Technology and Globalization Project
Agricultural Biotechnology for Development – socioeconomic issues and institutional challenges*

Belfer Center STPP

Kennedy School of Government

The diffusion of biotech crops in the Argentine agriculture sector

Daniel Chudnovsky

Paper presented at a workshop held at Bella Villagio, Bellagio Italy, 30 May – 1 June 2005.

The diffusion of biotech crops in the Argentine agriculture sector

Daniel Chudnovsky[1]

July 2005

Background

In a context of ample international financing, structural reforms introduced in Argentina in the early 1990s –among them, particularly the liberalization of the trade and capital accounts and a massive privatization policy- and the Convertibility Plan, played a major role in the elimination of inflation and the resumption of economic growth.

The Argentine economy registered high growth in 1991-94. After the recession in 1995 - due to the financial crisis (or tequila effect)-, growth was also substantial in 1996-1998. Despite the growing inequality in income distribution and increasing unemployment, Argentina was considered "the poster child" during the nineties for the implementation of the so-called Washington Consensus.

With the external shocks following the Russian and Brazilian crisis, the economy entered into a long recession in 1999-2000, and in 2001, into a financial, political and institutional crisis. The Argentine GDP was reduced in more than 20 % between the second quarter of 1998 and the first quarter of 2002.

The huge external debt was defaulted at the end of 2001 and at the beginning of 2002 the currency board was abandoned. The fall in the GDP and the huge devaluation of the peso sharply reduced imports and slightly increased exports, leading to a huge surplus in the current account that mitigated the large outflows of capital during 2001 and 2002. After a very difficult 2002 -in, which the economy collapsed, and the unemployment and poverty figures reached historical records-, the economy is growing again in a context of favorable international prices for commodities.

The intensification of agricultural production in Argentina during the 1990s and 2000s was one of the positive impacts of the structural reforms and of economic policies implemented at the beginning of the 1990s.

The elimination of taxes and withholdings on agricultural exports, the substantial reduction of import tariffs on inputs and capital goods and the deregulation of some markets, all created favorable macroeconomic conditions and paved the way for a large expansion of production volumes for grains and oilseeds (from 26 million tons in 1988–1989 to 67 million in 2001–2002) (figure 1), and particularly for soy -which soon became Argentina's leading export item. Soy exports that comprise not only soybeans but also flour and oil (figure 2) accounted for between one fifth and one fourth of total exports, depending on the

[1] Comments from Sakiko Fukuda-Parr and other participants at the Bellagio Conference are gratefully acknowledged. The usual caveat apply.

evolution of international prices. The steady increase in export value occurred within a context of erratic international prices and in the face of competition with other countries, which, unlike Argentina, profit from government subsidies to production and exports.

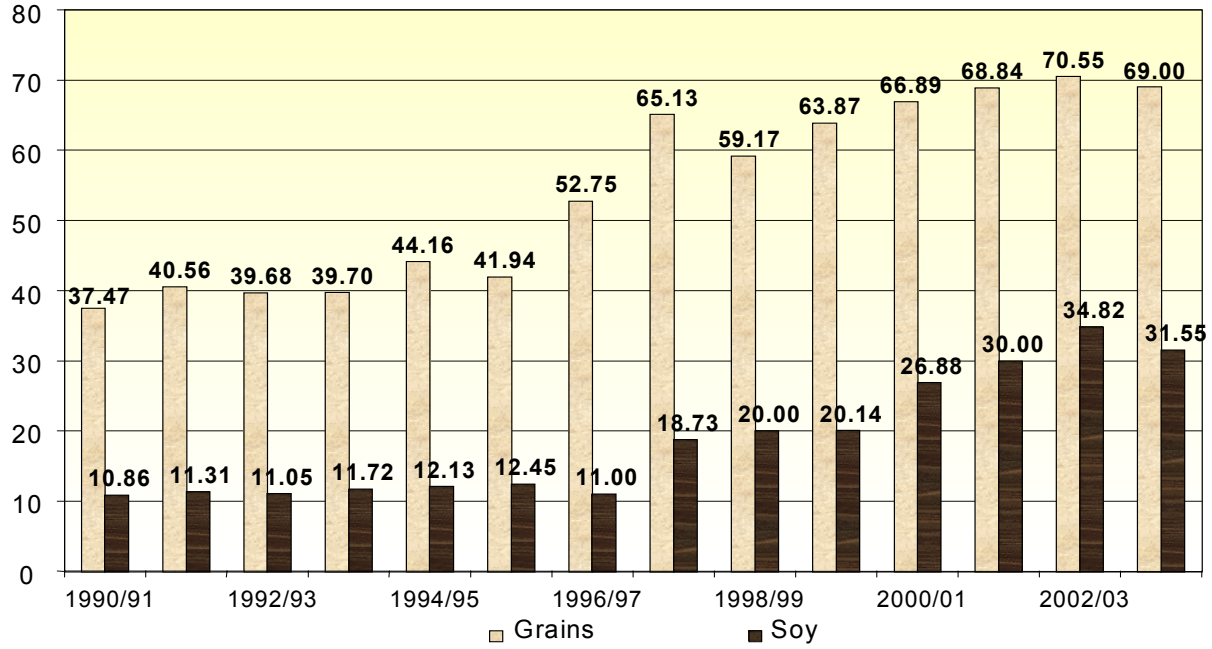
The huge peso devaluation at the beginning of 2002 favored the export oriented agriculture sector. More than 70 million tons (half of them soy) were produced in 2002-2003, to be reduced somewhat in the last season (see figure I)[2].

Argentina is the third largest world producer of soy (after the United States and Brazil) and is a leader in the international export market of soy. It accounted for 30 per cent of the market followed by the United States and Brazil with 25 per cent each (by translating oil and flour into to soybeans equivalents) in 2002 according to Ablin and Paz (2003). The vast majority of the soybean goes to the animal feed market. The main destination for soybeans produced in Argentina is China, the EU and Thailand. For soybean meal major buyers are the EU, Egypt, Malaysia and Thailand.

The government reintroduced the export taxes (20-23.5 per cent) in 2002 and has maintained them until now. These export taxes are a key source to finance the national welfare plan that the government established in 2002 to mitigate the huge increase of the population living under the poverty line.

FIGURE 1

Grains and soy production in millions of tons

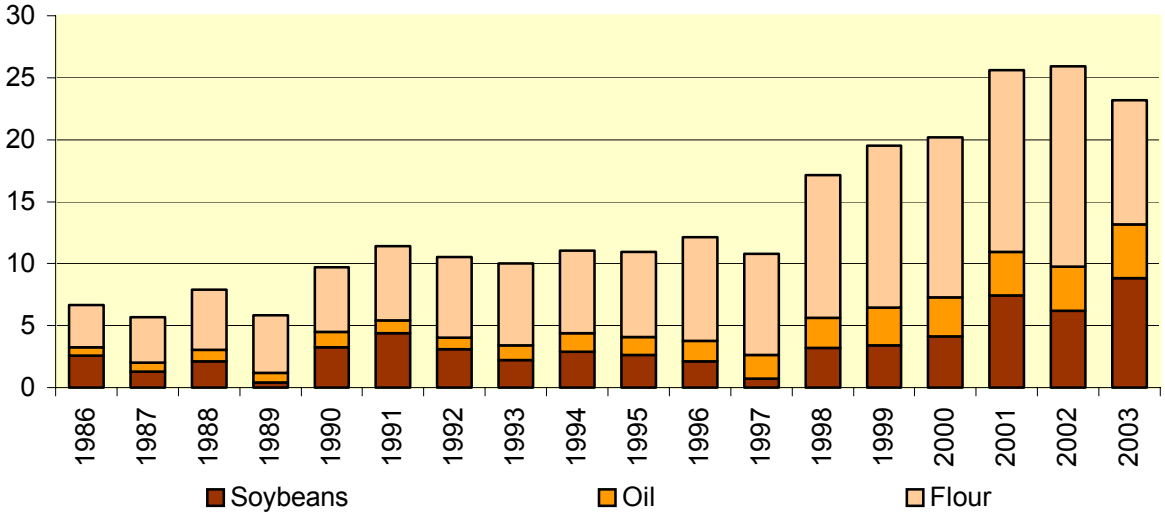


Source: Based on data supplied by the Secretariat for Agriculture, Livestock, Fisheries and Food, (SAGPyA).

[2] According to the last official estimate, a historical record of 84 million tons will be produced in 2004-5 of which soy will account for 38.3 million tons.

FIGURE 2

Soy exports in million of tons



Source: Based on data supplied by the Secretariat for Agriculture, Livestock, Fisheries and Food and CIARA

<u>The diffusion of GMO crops</u>

The growth in cereals and oilseed production is a result of mainly a substantial expansion of the planted area (basically at the expense of livestock) derived from a significant adoption of new technologies -notably the introduction of biotech crops in Argentine agriculture-.

The process of adoption of technologies involved the procurement of machinery and equipment, fertilizers and agrochemicals (herbicides and pesticides) as well as a momentous change in terms of genetic inputs: the introduction of transgenic crops in Argentine agriculture.

The first transgenic crop commercially released into the Argentine market -in 1996- was soybean tolerant to glyphosate herbicide. Later on, transgenic varieties of corn and cotton tolerant to herbicides and resistant to insects were approved by the local authorities (table 1).

The policy followed by the Argentine government was to approve only those events that have already been approved in the European Union.

When the EU authorized the import and sale of GM sweet corn lifting its five-years old import ban on May 2004 Argentina approved the RR corn in July of that year. And a few weeks ago it approved a new variety of corn resistant to lepidoptera and tolerant to ammonium glyphosate. This last approval took into account the technical opinion of the

European Food Safety Authority that considered that this type of corn has not harmful effect on human and animal health.

TABLE 1: TRANSGENIC EVENTS APPROVED FOR THEIR COMMERCIALIZATION IN ARGENTINA

Species	Introduced Feature	Transformation Event	Applicant	Resolution
Soybean	Tolerance to Glyphosate	"40-3-2"	Nidera S. A.	SAPyA N° 167 (3-25-96)
Corn	Resistance to Lepidoptera	“176”	Ciba-Geigy	SAPyA N° 19 (1-16-98).
Corn	Tolerance to Ammonium-Glyphosate	"T25"	AgrEvo S. A.	SAGPyA N° 372 (6-23-98)
Cotton	Resistance to Lepidoptera	"MON 531"	Monsanto Argentina S.A.I.C.	SAGPyA N°428 (7-16-98).
Corn	Resistance to Lepidoptera	"MON 810"	Monsanto Argentina S.A.I.C.	SAGPyA N° 429 (7-16-98)
Cotton	Tolerance to Glyphosate	"MON 1445"	Monsanto Argentina S.A.I.C.	SAGPyA N° 32 (4-25-01).
Corn	Resistance to Lepidoptera	"Bt 11"	Novartis Agrosem S.A.	SAGPyA N° 392 (7-27-01).
Corn	Tolerance to Glyphosate	“NK 603”	Monsanto Argentina S.A.I.C.	SAGPyA N° 640 (13-7-04)
Corn	Resistance to Lepidoptera and tolerance to Ammonium Gluphosinate	“TC 1507”	Dow Agrosciences Argentina S.A Pioneer Argentina S.A.	SAGPyA N° 143 (18-3-05)

Source: National Advisory Commission on Agricultural Biotechnology (CONABIA)

As from its release date, the rate of expansion of glyphosate-tolerant soybean in Argentina has increased considerably, exhibiting a growth even higher than the one in the U.S. -which was the first country to introduce this kind of crops-. The area planted to herbicide-tolerant soybean shot up from less than 1 per cent of the total area planted to soybeans, in the 1996/97 season, to 98 per cent in the 2004/05 season (14.5 million hectares).

The adoption of lepidoptera-resistant corn has also been of significance. From 20 per cent of the total cultivated area during the 2000/01 farming season (third year since its introduction) it has reached half of the cultivated area in the last season. However, the biotech cultivated area of corn is only 1,7 million hectares according to James (2004). The diffusion of Bt cotton has, in turn, been very limited, amounting to 7-8 per cent of the total planted area in 2000-01. Although it has reached 20 per cent of the cultivated area, only 25,000 hectares are cultivated with Bt cotton in Argentina (see James, 2004).

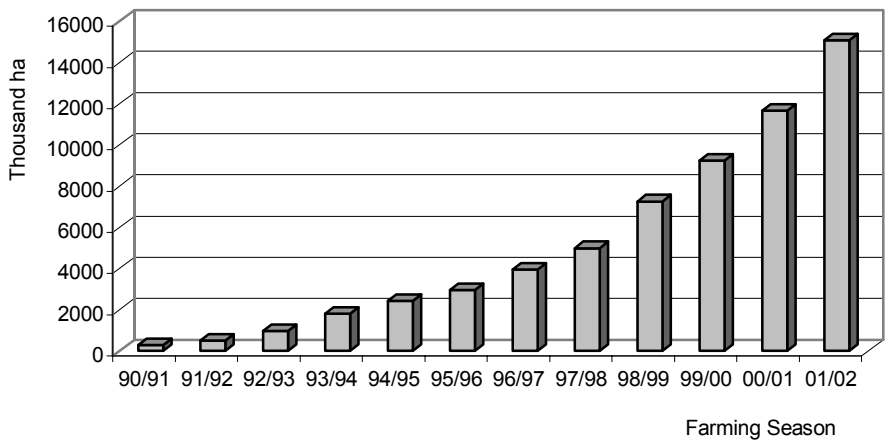
At present, Argentina ranks second, only to the U.S., in terms of agricultural surface cultivated with biotech crops and is therefore a major player in the international arena.

The sharp increase of Argentine agricultural production during the last decade has taken place hand in hand with the outstanding increase of no tillage[3] as the main farming practice for the Pampas crops (favored by the reduction in import tariffs for the agricultural machinery).

As can be seen on Figure 3, the use of this practice has increased from around 300,000 hectares in the period 1990/91 to over 14 million hectares in the 2001/2002 season.

FIGURE 3

Evolution of NT planting area



Source: Data supplied by the Argentine Association of Farmers for Direct Planting (AAPRESID)

This technology constituted an important factor in the expansion of production, as it increased the area cultivated with late-planted soybean -planted after the wheat harvest- to new production areas. During the 1999/2000 season, for example, this was translated into a virtual increment of 3 million hectares of arable land[4].

The combination of no-till planting techniques with herbicide-tolerant soybean joins two technological concepts: new mechanical technologies that modify crop interaction with the soil; and the utilization of general-use, full range herbicides -with glyphosate in first place-,

[3] No-tillage maintains a permanent or semi-permanent organic soil cover (e.g. a growing crop or dead mulch) that protects the soil from sun, rain and wind and allows soil micro-organisms and fauna to take on the task of "tilling" and soil nutrient balancing - natural processes disturbed by mechanical tillage.

[4] According to Benbrook (2005) of the 5.6 million hectares of land newly planted to soybeans in 1996-2003 , 25 per cent has come from conversion of cropland growing wheat, corn, sunflowers and sorghum, 41 per cent from conversion of forests and 27 per cent from conversion of former pastures.

which are environmentally neutral, due to their high effectiveness in controlling any kind of weed as well as their lack of residual effect[5].

While both factors imply a more intense use of inputs, this intensification was, at the same time, deemed "virtuous," because it simultaneously lowered the consumption of herbicides with the highest toxicity level[6].

It is worth noting that, even after the increase in the use of agrochemicals throughout the period, the total use per hectare of arable land was still far below the one recorded in other competing countries. Furthermore, the utilization of agrochemicals appears to have stabilized after the 1996-1997 season. If we also consider the favourable externalities generated through the progressive recovery of soil fertility along with other potential impacts -such as benefits on the greenhouse effect reaped from this type of practices- it seems that the overall environmental impact of these transformations was positive, at least until 2000.

Nonetheless, the INTA (2003) and the Secretary of Agriculture (in its web page section on main crops), among other analysts, have expressed serious concerns about the consequences of the soybean boom, since it has often been at the expense of abandoning crops rotation. In the Santa Fe and Cordoba provinces soy accounts for 80 to 90 per cent of the planted area with already serious problem of soil degradation and erosion. In the North and South West of the Buenos Aires province soy has expanded at the expense of corn and sunflower. Beyond the Pampas, the "agriculturization" process in the North East and North West of the country due to soybean expansion is unsustainable, since they are ecologically fragile areas. Both processes could affect both the quantity and quality of the country's natural resources endowment and may lead, in the future, to a fall in agriculture production.

Finally, although it is clear that a remarkable technology modernization process took place in Argentine agriculture during the 1990s, which allowed a substantial increase in production and exports, it is also true that the spillovers of this process for the rest of the economy were constrained by two facts:

i) The local agricultural machinery industry went through a restructuring process which implied not only plants closedowns as well as a strong reduction in domestic content of locally produced machines such as those required for no tillage;

---

[5] According to the classification of pesticides by hazard prepared by the WHO, glyphosate falls into the category of herbicidies of toxicity class IV which are the most benign ones. Qaim & Traxler (forthcoming) show that the adoption of RR soybeans in Argentina has led to an 83 per cent reduction in the use of herbicides with toxicity class II and that the use of herbicides with toxicity class II have been phased out

[6] However, Benbrook (2005) points out that reliance year after year on a single herbicide accelerates the emergence of genetically resistant weed phenotypes and this is, according to him, what is going to happen in Argentina.

ii) The new chemical and genetic technological packages that are increasingly key for agricultural production are provided by a handful of TNCs affiliates (see below) that seldom engage in biotechnology R&D activities in Argentina. This means that the locus of technological innovation, which in previous decades was mainly the Argentinean Pampas and carried out by public institutions such as INTA, has now been made abroad in the headquarters of the TNCs (Bisang, 2003).

The seed industry

The Argentine seed industry dates back to the 1950s and the country also have a long-standing tradition in the field of germplasm improvement. Originally, the industry was organized around the activities carried out by National Institute of Agriculture Technology (INTA) in the public sector, a group of small local firms (such as Buck, Klein and Morgan) specializing in wheat and corn and the subsidiaries of transnational corporations such as Cargill, Asgrow, Dekalb, Ciba Geigy, Monsanto, Novartis, Pioneer and Nidera.

In the late 1990s the local seed market was one of the biggest in the world and the second largest in Latin America. It reached a volume of over 1.9 million tons for a total value of over u$s 850 million in 1997 with soybean being, by far, the most important component, followed by corn as a distant second.

In the case of transgenic seeds, subsidiaries of transnational corporations generally own the genes and the technologies to incorporate them into the varieties and local companies develop the varieties, through different licensing and partnership agreements. Both types of companies are active in the conventional seed market and the subsidiaries of foreign firms are also active in agrochemicals and other business (Bisang *et al*, forthcoming).

The bio safety and other regulations

In addition to the significant seed industry, Argentina enjoyed favourable conditions for a rapid adoption of GMOs.

Key institutional decisions were made, particularly with regard to bio safety regulations with the creation of the Advisory Committee on Agriculture Biotechnology (CONABIA) in 1991 by a resolution of what was then the Secretary of Agriculture, Livestock and Fisheries.

CONABIA is a multidisciplinary organization with advisory duties made up by representatives from the public sector, universities and from organizations in the private sector related to agricultural biotechnology. The members perform their duties as individuals and not as representatives of the sector they come from.

CONABIA handles applications for laboratory and greenhouse testing, field trials and flexibilization of genetically modified plants. It also advises the Secretariat on issues related to trials and/or the release into the environment of GMOs and other products that may be derived from or contain GMOs.

CONABIA does not have a structure of its own. It acts through the institutions and regulations that make up the regulatory system of the agriculture sector. These are the National Institute of Seeds (INASE) created in 1991 in charge of regulating seed trade and ensuring the availability of quality seed by preventing frauds and forgeries (for which it had been vested with police powers) and the SENASA (National Agricultural Food Health and Quality Service) regulating, among other things, food safety and quality including GMO-derived food.

The 1973 Seeds and Phytogenetic Creations law that awards breeders rights in the creation and discover of plant varieties adopts the principles of the UPOV 1978 Act to which Argentina adhered formally in 1995. In this respect, there are exemptions in favour of the parties that carry out plant improvements and for farmer who save seed for their own use. The legal framework was completed with the creation in 1991 of the Argentine Association for the Protection of Plant Breeding (ARPOV) that include all parties involved in the development of varieties. ARPOV is responsible for managing license agreements of varieties under the condition that seed production is to be conducted in Argentina.

It is worth noting that the structure of INASE was changed at the end of 2000. It became an area of the Agriculture Secretary. The downgrading of the institutional status of INASE not only reduced its efficiency and flexibility but also facilitated the growth of the illegal trade in seeds (see below). In November 2003, INASE was established again as a decentralized organization with a new board of directors.

A new patent law was approved in 1995 and enacted in the year 2000. In contrast to the previous law, the new one allows the patenting of pharmaceutical products. It is consistent with the provision of the TRIPs agreement and authorizes patenting biotechnological products and processes as long as the product meets the required patenting conditions, i.e. they are new, involve an inventive step and has industrial applications.

The aforementioned elements, along with the fact that Argentina constitutes a major area - amounting to 26 million ha of cultivable land- for the potential use of new technologies outside their country of origin, provided the proper incentives and a most suitable “landing field” for the rapid adoption of these biotechnological inputs.

Idiosyncratic institutional factors in the diffusion of GMOs

Besides the mentioned features of the regulatory framework, a number of idiosyncratic factors played an important role in the diffusion of biotech crops and especially of RR soybean.

The first factor refers to the manner in which the RR gene was first transferred to Argentina. Originally, access to the RR gene was achieved through negotiations between Asgrow and Monsanto in the United States, whereby Asgrow Argentina was granted the use of the gene in its registered varieties. Later on, when Nidera acquired Asgrow Argentina, it gained access to the gene and widely disseminated it in Argentina.

Consequently, when Monsanto requested to revalidate in Argentina the patent of the gene in 1995, it was unable to do so because it had already been "released".[7]

However, through private settlements that expressly identify the ownership over this patent and stipulate the royalties to be paid, Monsanto was able to license the RR gene to other companies that have commercialized it in Argentina[8]. Therefore, conditions were never met for the breeder company -i.e. Monsanto- to be entitled to charge the technology fee nor to restrict the use of the seed by farmers, as it is the case in the U.S.

The second factor is related to the operational aspects of the seed market and its effect on the price of RR soybean. On the one hand, as mentioned and under the UPOV Convention of 1978, farmers can legitimately keep seeds for their own use; on the other hand, there are clandestine operations (the so-called "white bag") through which seed multipliers offer seed without the authorization of the companies holding the corresponding legal production rights. Both factors have driven down the price of RR soybean, thus promoting the rapid adoption of the technology.

Within this context, the growth of the seed market should come as no surprise, regardless of the sharp increase observed in the surface planted to soybean -the leading crop in such market-. Therefore, the plateau experienced by the seed market as from the years 1996/97 may be explained by the introduction of transgenic seed and the resulting need of obtaining original seed on the part of farmers (and even of clandestine seed producers). The use of "white bag" seed as well as of farmers' own seed would account for the evolution of the market in the following years, a practice which surely had an impact on the substantial reduction in the price of RR soybean seed as compared to that of conventional seed.

It should be noted that this situation is also linked to the fact that soybean seed falls into the category of autogamous species, in which genetic quality can be maintained through seed retained by farmers for their own use -or which may be used for clandestine multiplication practices-. Along these lines, we should also take into account the relevance of the widespread adoption of the wheat-soybean double-crop system during the period under analysis, which undoubtedly constituted an additional inducement to keeping seeds for the next season.

The third factor contributing to the wide diffusion of RR soybean in Argentina was the increasing reduction in the price of glyphosate, which stemmed from a fiercer competition in local markets by dint of the introduction of new agents in the manufacturing and commercialization of said product[9].

---

[7] Monsanto states that the patent request made in 1995 was rejected in 2001 by the Supreme Court of Justice in a polemical interpretation of the validity of the revalidated patent request and the entry into force of the new patent law. Monsanto considered that this interpretation not only affected it but also dozens of companies that requested revalidated patents (www.monsanto.com.ar/tecnologiarr). According to the Argentine government, Monsanto made the request to revalidate the patent after the 12 months allowed by the law in force.

[8] Monsanto has started to commercialise its own RR varieties since 1999.

[9] Monsanto also made the glyphosate in its Argentine manufacturing plant and filed an antidumping procedure against imports of that product from China. After a year and half process, in February 2004 the government decided against Monsanto claim, a decision widely supported by the agriculture sector.

Unlike RR soybean, Bt corn and Bt cotton feature a much less dynamic performance. Firstly, Bt varieties have been released much more recently, and secondly, farmers tend to consider Bt crops as some sort of insurance, yielding higher or lower profits depending on pest behaviour during each season. In addition, a technology fee to be charged to farmers is applicable to transgenic corn and cotton varieties and, in some cases; this fee is higher than in the U.S.. This is related to the fact that, in both crops, there are patent applications for the involved events and that, in the case of corn, it is a hybrid variety. As a consequence, farmers may not keep their own seed for planting, and therefore, the relative weight of the certified seed in the corresponding market increases.

As far as cotton is concerned, the real issue lies on the commercialization strategy, which is based on formal agreements between the sole supplying company and the farmers, whereby the latter's right to their "own use" of the seed is restricted. As a result, farmers have no choice but to pay for the seeds four times the price of conventional varieties, and this, in turn, hinders the diffusion of this technology in the country.

It is clear from the above discussion that one of the main problems in Argentine agriculture is the illegal trade of seeds, amounting to 35-50 percent of the market[10]. Besides the risks that this situation might entail in terms of a potential reduction in productivity (seed with lower genetic quality and germinatory power) or with respect to phyto-sanitary issues, the existence and growth of illegal practices might also mean that many of the breakthroughs in biotechnology -and in other conventional technologies as well- may not find an effective way to be incorporated into production. In other words, the dissemination of new knowledge takes much longer than it actually would if the seed market worked under normal conditions.

To start to deal with this serious situation, in July 2003 the Agriculture Secretary passed a resolution to oblige farmers to inform the amounts of seed used or to be used in the next season to plant wheat, soy and cotton. It seems that this measure contributed to increase the use of registered seeds from only 20 per cent of the planted surface in 2003 to 32 percent in 2004 (La Nación, 10 July 2004).

At the same time, the Agriculture Secretary prepared a new law to be discussed in Parliament to establish a royalty to seed producers that received strong opposition from all parties. Later on INASE prepared a law project to conform a "Fiduciary Fund for technological compensation and incentive to the production of seeds". By this initiative it is expected to charge a fee between 0.35 and 0.95 per cent of the price in the first sale of the crop, at the beginning only for soy and wheat. With the funds to be collected a royalty should be paid to the breeders and resources should be available to finance new varieties. Furthermore, when the farmers could prove that they are using legal seeds they may receive a compensation in the taxes to be paid to the government.

[10] The illegal seeds market (50 per cent according to the company) in contrast to 18 per cent of the seeds that are certified and 32 per cent self produced by the farmers) has been the main reason that led Monsanto to close its soy bean business in Argentina at the end of 2003 arguing that it was not profitable (La Nación, 21 December 2003). It is likely that the news of an adverse decision on glyphosate imports also influenced the company.

Given the opposition to this initiative, a new project was prepared restricting the own use of seeds only up to 65 hectares. Several criteria are suggested for the paid use of seeds, with time limits according to the crop but no consensus has been yet reached among the different parties.

Due to the failure to reach an agreement among the different parties on the seed issue, in September 2004 Monsanto decided not to charge any royalty for the RR soy to the licensed seed companies in Argentina for the 2004-05 season. At the same time, the company threatened to charge a u$s 15-per-metric-ton fee on Argentine soybean exports in the countries where the technology is patented. If exporters would decline to pay the fee, they should face the prospect of being sued in the courts of European countries that import Argentine soybeans in 2005. The Argentine government considered this as an unacceptable threat without any legal basis.

In the mean time, several proposals made by Monsanto to the agriculture producers have been rejected. The last one included a royalty of u$s 1 per ton during the 2004-5 and 2005-6 seasons and a ceiling of up to 3 per cent of the domestic value of soy starting in the 2006-7 season and until the expiration of the patent (www. monsanto.com.ar/tecnologiarr).

At the end of June 2005, Monsanto has started legal actions in the Netherlands and in Denmark to obtain the royalty from Argentine soy exports in ships that reached those markets. The Argentine government strongly rejected the company action and decided to participate, through the Ministry of Foreign Affairs, in the juridical trials as an involved party.

Whereas conversations among the private and public interested parties continue, their big differences have prevented so far an agreement on this key issue.

Research and development efforts

Public (and private) resources allocated to research and development in Argentine in all fields and in agriculture -especially in the area of biotechnology- are scarce as compared to corresponding efforts at the international level.

As a percentage of the GDP, expenditure in scientific and technological activities in Argentina increased from 0.33 per cent in the early 1990s to 0.52 percent in 1999. During the recession and crisis years it decreased to only 0.44 in 2002 to augment to 0.46 in 2003. R&D expenditures after reaching 0.45 per cent of GDP in 1999 registered a decreasing trend and they were only 0.39 in 2002. In 2003, they increased again to reach 0.41 per cent of GDP.

Agriculture accounted for 18 per cent of the expenditures in R&D and for a similar percentage as a field of application of R&D projects in 2003.

While the financial resources are scarce, it is important to bear in mind that the country has a sizable human capital: 27,367 full time researchers in 2003. Most of them worked in public universities and institutes.

Regarding biotechnology, according to a survey made in the year 2000 by the International Service for National Agricultural Research to 18 research organizations (out of 41 contacted ones), the country had about twelve organizations with major capabilities in molecular biology and generic engineering, which employed approximately 300 researchers. The resources devoted to research were U$S 3.5 million excluding researchers salaries. These organizations were mainly located in the public sector and in public universities. Major laboratories include the INTA´s Castelar Institute (Biotechnology, Genetics, Plant Physiology, Veterinary Sciences), the Institutes of Genetics and Biotechnology –INGEBI (Conicet)), the Institute of Biochemical Research at the Campomar Foundation, the Center of Photosynthetic and Biochemical Studies- CEFOBI- (Conicet), the Center of Animal Virology- CEVAN (Conicet), the laboratories of some public universities such as Universidad Nacional de la Plata, Universidad Nacional de San Martin and Universidad Nacional de Tucumán and the agricultural division of Bio Sidus, this last one in the private sector (Cohen et al, 2001).

An ongoing survey of biotechnology firms in Argentina indicates that in 2002-03, the seventy-one surveyed firms devoted 0.9 per cent of their sales to R&D. In agriculture biotech, seed firms assigned 0.52 of their sales to R&D (Bisang et al, forthcoming).

The low figures that both public and private institutions devote to R&D in biotechnology represent a dramatic contrast with the resources assigned not only in the United States but also in developing countries such as China and Brazil.

Besides the low resources, there is a great diversity in research focus. According to the ISNAR survey, agriculture related applications include the diagnosis of phytopathogens in several crops, the development of biological control agents and the use of micropropagation techniques, molecular markers and genetic engineering of different crops such as garlic, onion, potatoes, sunflower, corn, wheat alfalfa, strawberry, tomatoes, rye, citrus, cranberries, sugar cane and yerba mate (Cohen et al, 2001)

In the recently approved Strategic Plan 2005-2015 for the development of agriculture biotechnology (Ministerio de Economía, 2004), it is pointed out that although the country has a good research capacity in life sciences as reflected in the three Nobel Prizes obtained by Argentine researchers, this not the case in modern biotechnology.

In view of the relatively few biotech plants and industrial developments in the country, the demand for professionals in this area has been limited. Training of more human resources is required in biotechnology. However, it is noted that the Argentine biotech industry has important capabilities regarding access to information, lab techniques, modern equipment and participation in international networks. It is a tool user in agriculture biotech and has excellent facilities for improving and adapting new plant varieties.

Nonetheless, beyond their meaningful contribution to R&D activities on some crops (such as alfalfa and potato) and into the sphere of veterinary science, institutes devoted to agricultural biotechnology research in Argentina have hardly participated in the events approved by the CONABIA.

As shown in table 2 there have been transnational corporations that in Argentina -as well as in many other countries- have taken the lead in the process of field trials into the environment. They have mostly focused their field trials on corn and soybean (table 3). Given that the Argentine crop growing areas are analogous to those in the northern hemisphere for which the technologies were originally developed, transnational firms have to bear only the costs of backcrossing the new genes into already existing varieties well adapted- a process which is much simpler than the actual development of a GMO variety.

As already mentioned there are a number of local private breeders that have been able to keep their businesses by partnerships with TNCs affiliates; the latter provide the transgenic genes that are combined with varieties well adapted to local conditions that are owned by local breeders (Bisang, 2003).

TABLE 2: PERMITS FOR THE RELEASE OF GMOs INTO THE ENVIRONMENT(FIELD TRIALS) BY TYPE OF ORGANIZATION

	1991/93	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
Transnational corporations	11	17	26	28	62	65	70	52	49	62	93	96	631
Local companies	8	4	6	6	12	12	10	10	4	4	5	19	100
Government agencies	2		4	6	4	13	1		8	1	1	5	45
Universities								3	2	3		1	9
Total	21	21	36	40	78	90	81	65	63	70	99	121	785

Source: Own elaboration on data from National Advisory Commission on Agricultural Biotechnology (CONABIA)

TABLE 3: PERMITS FOR THE RELEASE OF GMOs INTO THE ENVIRONMENT (FIELD TRIALS) BY TYPE OF CROP

	1991/93	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
Soybean	3	5	9	5	7	12	10	15	10	11	18	13	118
Corn	8	10	18	23	41	40	44	22	23	42	58	96	425
Cotton	4	2	5	4	7	4	5	9	8	3	1	2	54
Wheat	1		1	2	2	2	1	3	3	1		3	19
Sunflower		2		2	17	24	18	7	4	3	1		78
Potato			1	1	2	3	1	4	3			5	20
Alfalfa					1	4		1	8	1			15
Others	5	2	2	3	1	1	2	5	4	9	22	4	60
Total	21	21	36	40	78	90	81	66	63	70	100	123	789

Source: Own elaboration from data of National Advisory Commission on Agricultural Biotechnology (CONABIA)

Economic and social impacts

Regarding the economic and social impact of biotech crops, there is good information on the distribution of benefits between input suppliers and farmers based on our own research (Trigo *et al* 2002)[11]. Some information is available on the growing concentration of agriculture production and on employment creation but research is required to analyze its relationship with biotech crops diffusion.

a) Distribution of benefits among farmers and input suppliers

In the case of RR soybean adoption the benefits are derived from the reductions in the production costs and from the way this reduction has impacted over the area planted with soybeans. The extra income which would have not been generated in the absence of this technology until the year 2001-02 (by comparing two alternative scenarios with and without RR soy) were estimated in u$s 5.2 billion.

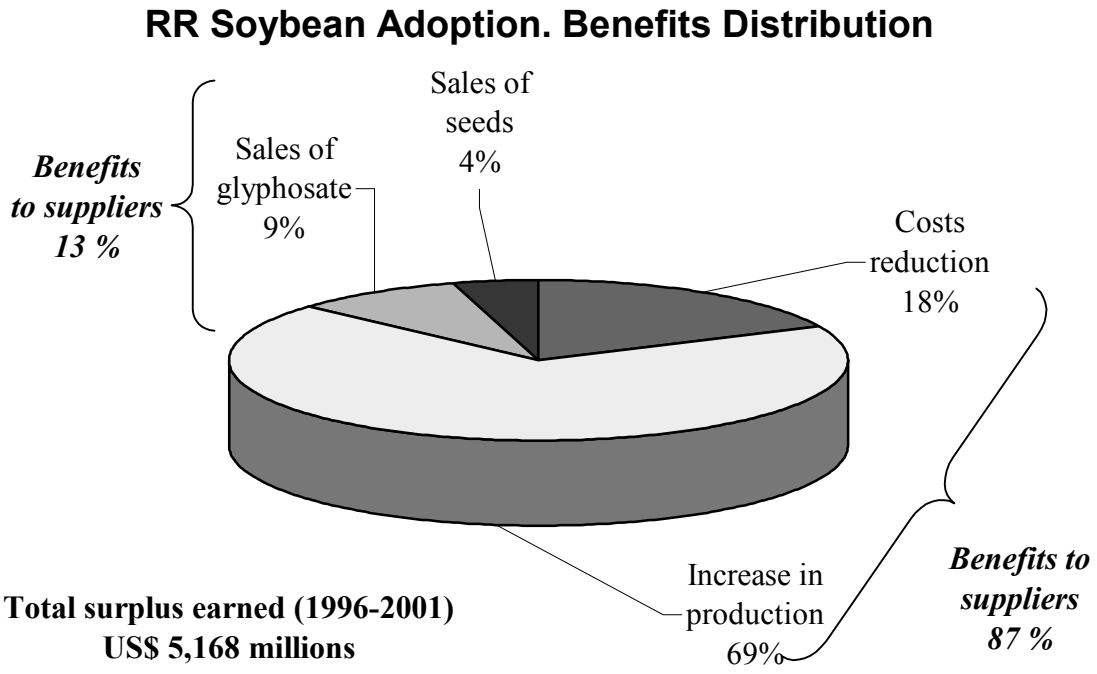
Following the same methodology, in the case of Bt corn the benefits were estimated in u$s 400 million and in Bt cotton in u$s 40 million.

As shown in figure 4 most of the benefits of RR soy bean adoption ended up in the hands of farmers who capture more than 80 per cent of the total, mostly due to increase in production. The benefits to input suppliers have been relatively low. If the “white bag” had

[11] Qaim, M. and G. Traxler (forthcoming) estimated the benefits with a different methodology. They include benefits to consumers which are very low as compared to those accruing to producers.

existed, input suppliers would have increased their share in the overall benefits from 13 to 18 per cent (table 4) . Still the lion´s share of the benefits would have accrued to farmers rather than to input suppliers.

FIGURE 4



Source: Trigo *et al* , 2002

The evidence available for Bt corn and Bt cotton (see table 4) does not point in the same direction. Input suppliers account for most of the benefits both in the case of Bt corn and Bt cotton. While in the case of Bt corn where protection comes from the hybrid nature of the seed, the importance of IPR is clearly shown in Bt cotton. Quaim (2002) shows that adoption rates would be much higher if seed pricing policies by the technology supplier had been more flexible.

TABLE 4: TRANSGENICS IN ARGENTINE AGRICULTURE: DISTRIBUTION OF GROSS ACCUMULATED BENEFITS, PERCENTAGES

Case		Farmers	Input providers
SOYBEAN RR	Without “white bag”	82	18
	With “white bag”	87	13
COTTON Bt		17	83
CORN Bt		21	79

Source: Trigo et al, 2002

b) The increasing concentration of production

The available information indicates that there has been a strong process towards concentration of the land. A study carried out by Mora & Araujo (Mora & Araujo, 2000) showed that, between 1992 and 1999, the number of farms dropped from 170,000 to 116,000, i.e., a 32 per cent reduction. At the same time, there has been an increase in the median size of farms, from 243 to 357 hectares.

The classification by size (small, medium and large) proposed by Pucciarelli (1997) takes into account a different set of parameters and is more precise than grouping them by area. When the analysis is done according to this classification, it is found that, from 1993 to 1999, small farms decreased from 85 per cent to 69 per cent; medium ones increased from 9 per cent to 18 per cent, and large ones, from 6 per cent to 13 per cent. In the same manner, by 1999, the area accounted for by each group was: small farms, 28 per cent; medium farms, 23 per cent and large farms, 49 per cent[43].

Data from the recently released Agricultural Census of 2002 completes the picture from previous studies. Comparing data for 2002 with that of the previous Census in 1998, the number of farms decreased from 421 to 332 thousand (i.e. –21 per cent) and the average surface of the unit increased from 421 hectares to 518 hectares in the whole country. In the Pampas, the reduction in the number of farms was sharper (29 per cent) and the increase in the average surface higher (36 per cent) than in the rest of the country (Lazzarini, 2004).

According to some experts, the reduction in the number of farms –mainly small and medium size ones- is associated with the phenomenal expansion of RR soy. Furthermore, the surviving farms are forced to buy the seeds and the agrochemicals to the affiliates of TNCs (Teubal, 2003). Unfortunately, this association and its causality have not been properly tested and no references are made in the said paper to the reduction in the price of seeds and in agrochemicals and to the illegal trade in seeds.

It has also been argued that the incorporation of new technologies led to huge indebtedness levels and hence many small farmers were not able to continue with their production activities because of the burden of the debts (Bisang, 2003).

While it is true that the machinery required for no till farming is expensive and hence only big farmers afford to buy them, most medium and small size farmers can hire the machinery to specialized firms that provide those services. Furthermore, in a microeconomic study on RR soy diffusion in Argentina, Qaim and Traxler (forthcoming) did not find any adverse effect of the new technology on small farmers.

In the case of Bt cotton, we found that farmers with low technological capacity (generally small ones) receive 12 per cent of the benefits and account for 27 per cent of the planted

[43] Mora & Araujo's work uses the "farm" concept to refer to those production units under the same management and not necessarily the same ownership, since there has been a remarkable increase of farm renting.

surface. Regarding Bt corn, farmers with low technological capacity receive 13 per cent of the benefit and cultivated 21 per cent of the land. Although the more expensive seeds area clear disadvantage for small farmers, its access could be facilitated through trade credit, though this type of credit is generally expensive.

In contrast, the access to the specialized agricultural equipment would require long-term credit lines and a change in the production process. As mentioned above the development of firms specialized in hiring the machinery to small and medium size farmers may have mitigated this problem.

In any case, further research on the impact of the diffusion of biotech crops in small and medium size farmers is required.

c) Employment trends

The diffusion of labor saving technologies through growing mechanization and tractorization and, over the last three decades, the increase of the average power of equipment facilitating scale economies, has an impact on rural employment.

The number of direct jobs in the sector felt from 1,86 million in 1926 to 783,000 in 1993.[46] However, since that same year, the trend has significantly reverted to reach 966,000 jobs in 1999 (latest available year)[12]. This positive difference of nearly 200,000 jobs is likely to be the result of the simultaneous processes of agriculturization (crops substituting for livestock) and intensification of production systems based on bio tech crops[13].

The introduction and rapid expansion of late-planted soybean (planted after the wheat harvest), has played a substantial role. Concerning the 1999-2000 season, this practice implied a virtual increase of 3 million hectares of arable land, and thus, additional demand for labor. The most remarkable aspect is that this increase in the employment level took place simultaneously with (i) an increase in partial productivity of labor in the primary sector of 3.26 per cent per year for the period 1990-97; (ii) an almost five point increase in the total unemployment of the Argentina's economic rate. Thus, the technological package seems to have had positive effects from a social perspective, at least in what concerns job creation (Trigo & Cap, 2003).

Concluding remarks

Keeping in mind that so far Argentina has encountered no difficulties in accessing target markets for its RR soybean exports and that, in spite of the perceptions of foreign consumers, price differentials between conventional and RR soybeans in the world market

---

[46] This reduction of nearly one million jobs had a negative aspect: the laying off of labor (socially undesirable effect), and a positive one as well: the amazing increase in productivity of workers, made possible by modern mechanical technologies, a fact which has enabled the sector to maintain its international competitiveness throughout the XX century.

[12] According to a study by Llach et al (2004) based on the Input Output table of the argentine economy for 1997, employment in the primary agricultural sector increased in more than 270 thousand.

[13] It is possible that part of the increased labor demand is due to labor requirements in areas outside the Pampas or in other crops. Information yet to be processed from the latest Agriculture Census would shed light on this issue.

do not penalize the latter, it is hardly surprising that almost all Argentine soybean crop is RR.

Neither is it surprising that not only input suppliers but also farmers, the scientific community and government authorities are all in favor of this new technology as clearly reflected in the collective preparation of the Strategic Plan 2005-2015 led by the recently created Office of Biotechnology.

According to the first national survey on public perception of science made in 2004 by the Secretary of Science and Technology most of the population accepts the agricultural use of biotechnology. The main concern is the access to healthy and sufficient food. Only a few NGOs, especially Greenpeace, have introduced part of the international debate in Argentina. It is also true that in some provinces and due to local NGOs there are law projects under discussion to make labeling of GMOs compulsory.

Nonetheless, the extraordinary success of the RR soybean should be taken in a more cautious way if a long-term view is considered.

First, it may affect the fertility of the soil for an excessive reliance on this crop, pushed by the high international prices. In this connection, a report by the National Institute of Agriculture Technology (INTA, 2003) states that the “no tillage system + RR soybean” cannot go on as a sustainable strategy without rotating crops in the Pampas. At the same time, the “agriculturization” process in the North East and West of the country due to the soybean expansion is not sustainable in these ecological fragile areas. Both processes could affect both the quantity and quality of the country’s natural resources and lead to a fall in agriculture production.

Although according to INTA (2003), more sustainable production methods (based on rotation with corn and livestock) are available and are being adopted by some farmers despite their higher operating costs, the fact that 50 per cent of the land is leased and the price of the lease is fixed in kg of soybeans is a serious constrains for the diffusion of these methods.

While the recent release of new transgenic corn varieties and lower international prices for soybean may make more attractive for farmers to plant less soy and more corn, the mono cropping issue is a very difficult one. Beyond many discussions in technical meetings, no serious attempt to deal with this issue at a political level is visible.

Second, the trend towards a differentiated world market for GMO and non-GMOs products in view of the increasing eco labeling requirements in import markets (to meet the consumer fears on these type of food items) may negatively affect the prices in which Argentine producers sell their oil seeds.

The way the WTO proceeds in the conflict regarding the GMO moratorium between the European Union and the United States, Canada, Argentina and other GMO producing countries may also influence Argentine exports to the world market.

Third, the difficulties in finding a compromise solution with Monsanto on the fee for the RR technology and generally on finding incentives for the seed industry development and measures to curbe the illegal trade in seeds are clear indications of the institutional problems the country is facing to make further advances in this technology. Furthermore, the relatively low hierarchy of the legal and institutional framework of CONABIA and the limited research capacity on biosafety are important issues to be addressed (Burachick & Traynor, 2001).

At the same time, the domestic policy process regarding biotechnology should be reexamined. It would be quite important to analyze ways in which leading stakeholders could become more responsible for the long term effects of these technology advances and give more participation to stakeholders which have been largely ignored in the policy process like the Parliament, consumers and environmental NGOs. In this connection, an important initiative mentioned in the Strategic Plan for Biotechnology is to establish public hearings before new events are approved for commercialization.

Fourth, the possibilities of increasing the financial and human resources for allowing a greater participation of local firms and institutions in the research and monitoring processes that so far was basically influenced by affiliates of foreign companies should be considered.

This is precisely one of the main points of the Strategic Plan for Biotechnology but it is not clear how the good intentions of this Plan are going to be translated into actual financial resources for research and for increasing the training and development of the human resources in this critical area.

It is also surprising that neither research priorities for local efforts nor specific ways to obtain positive spillovers from the activities of foreign firms in Argentina are discussed or even mentioned in the Strategic Plan.

Fifth, more research is required on the socio economic impact of bio tech crops. The impact of this technology on the growing concentration of production and especially on small and medium size farmers is a key issue on which little research is available.

The distribution of benefits between input suppliers and farmers should also be further studied in soy, corn and cotton specially in view of the changes in relative prices that have taken place after the peso devaluation in 2002 and the existance of withholding taxes.

Finally, more research is also required on the environmental impact of bio tech crops in Argentina taking into account not only the mentioned mono cropping issue but also the excessive reliance on glyphosate, the growing use of fertilizers, the impact on health and on biodiversity.

References

Ablin, E. & S. Paz (2003), *El Mercado Mundial de Soja. La República Argentina y Los Organismos Genéticamente Modificados*, Centro de Economía Internacional, Trade and International Economic Relations Secretariat, Ministry of Foreign Affairs, International Trade and Worship, Buenos Aires.

Benbrook, Ch. (2005), "Rust, Resistance, Run Down Sils, and Rising Costs. Problems Facing Soybean Producers in Argentina", Technical Paper Nbr 8, January, Ag BioTech InfoNet

Bisang, R. (2003), "Apertura Económica, Innovación y Estructura Productiva: La Aplicación de Biotecnología en la Producción Agrícola Pampeana Argentina", *Desarrollo Económico*, Vol.43, Nbr 71, Buenos Aires.

Bisang, R. A. Diaz & G.Gutman (forthcoming) Empresas biotecnológicas en Argentina (mimeo)

Burachik, M. and P. Traynor (2001), *Commercializing Agricultural Biotechnology Products in Argentina: Analysis of Biosafety Procedures*, International Service for National Agricultural Research ISNAR, The Hague, The Netherlands.

Cohen, J., J. Koimen and J. Verástegui (2001), "Plant Biotechnology Research in Latin American Countries: Overview, Strategies and Development Policies", Prepared for *IV Latin American Plant Biotechnology Meeting*, REDBIO, Goiania, Brazil.

INTA (2003), *El INTA ante la preocupación por la sustentabilidad de la producción agropecuaria argentina*, Buenos Aires.

James C. (2004), "Global Status of commercialized biotech/GM crops ", ISAAA Briefs Nbr 32

Lazzarini, A. (2004), "Avances en el análisis del CNA 2002 y su comparación con el CNA 1988", Documento preparado para el proyecto *Sistematización y análisis del Censo Nacional Agropecuario 2002*, Instituto de Economía y Sociología, INTA, Buenos Aires

Llach, J., M. Harriague y E. O'Connor (2004), "La Generación de Empleo en las Cadenas Agroindustriales", Fundación Producir Conservando, Buenos Aires.

Ministerio de Economía y Producción (2004) Secretaria de Agricultura, Ganadería, Pesca y Alimentos, Oficina de Biotecnología "Plan estratégico para el desarrollo de la biotecnología agropecuaria 2005-2015"

Mora y Araujo (2000) www.bolsadecereales.com

Pucciarelli, A. (1997), "Estructura Agraria de la Pampa Bonaerense: Los Tipos de Explotaciones Predominantes en la Provincia de Buenos Aires" en Barsky, O. and A.

Pucciarelli (eds.) (1997), *El Agro Pampeano: El Fin de un Período*, FLACSO, Universidad de Buenos Aires, CBA Publications Office, Buenos Aires.

Qaim, M. (2002), "Bt Cotton in Argentina: Analyzing Adoption and Farmer´s Willingness to Pay", Unpublished manuscript.

Qaim, M. and A. de Janvry (2003), "Bt Cotton and Pesticide Use in Argentina: Economic and Environmental Effects" accepted for publication in *Environmental and Development Economics*

Qaim, M. and G. Traxler (forthcoming), "Roundup Ready Soybeans in Argentina: Farm Level Environmental and Aggregate Welfare Effects" accepted for publication in *Agricultural Economics*.

Teubal, M. (2003), "Soja transgénica y crisis del modelo agroalimentario argentino" *Realidad Económica*, Nbr 196, Buenos Aires.

Trigo, E. y E. Cap (2003), "The Impact of the Introduction of Transgenics Crops in Argentinean Agriculture", *AgBioForum*, Vol 6, Nbr 3, University of Missouri.

Trigo, E., D. Chudnovsky, E. Cap y A. López (2002), *Los Transgénicos en la Agricultura Argentina: Una Historia con Final Abierto*, Libros del Zorzal/IICA, Buenos Aires.