Towards a National Innovation Fund for strategic investment

in agricultural biotechnology in Argentina

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Since 1975 Argentina has experienced 45 years of slow growth, stagnant GDP per capita and recurrent balance of payment crises. In addition to macroeconomic mismanagement, this erratic development trajectory is explained by the stagnation in productivity and exports. There is increasing consensus that in order to break this path, the country needs to put in place policies and institutions to promote technological innovation, which is the basis of structural transformation and long-term economic growth[2].

Agricultural biotechnology has the potential to serve this objective and Argentina has certain advantages to generate a local base of competitive and innovative biotech firms. Biotechnology has the potential to improve productivity and sustainability of agriculture and, at the same time, promote linkages from agriculture to a knowledge-intensive activity capable of generating spillovers to other sectors, contributing to the diversification of the productive structure.

A good starting point is that, in a country in which majority political parties struggle to find common long term agendas, the promotion of agricultural biotechnology appears as an important exception. However, the results so far have been disappointing and local firms struggle to compete in an activity largely dominated by MNCs. As a consequence, the aim to diversify the economy through the promotion of agricultural biotechnology is still far from sight and agricultural production remains strongly dependent on the adoption of technologies developed by MNCs.

The main argument of the paper is simple: to promote innovative local agri-biotechnology companies, it is necessary to increase private and public R&D and, in order to do that, rules affecting the distribution of technological rents should be revised. The proposal of this paper is to create a National Agri-biotechnology Fund to strengthen local technological and innovation capabilities and finance a national agri-biotechnology development strategy. The evidence collected for this paper included a review of existing studies and official reports on agricultural biotechnology in Argentina, as well as more than 20 interviews with key actors from the public and private sector.[3]

The paper is organized as follows. The first section provides the reasons why Argentina should implement policies to promote agricultural biotechnology. The second section provides a diagnosis of existing local productive and technological capacities in agricultural biotechnology. The third section provides evidence of why low public and private investments in R&D are holding back local technological and productive capabilities. The fourth and last section presents the main features of the proposed innovation fund.

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[2] Innovation, defined as the process to create knew knowledge and commercialize it, allows producers to set higher prices, increasing the rents of the country (Reinert, 1996)

[3] This paper builds on ongoing projects on agricultural biotechnology carried out by the research team of Natural resources and development at Buenos Aires-based think tank Fundar.

1. Justification: why should Argentina implement policies to promote agricultural biotechnology?

Historically, debates in Latin America about productive diversification and promotion of technology-intensive activities, were framed in terms of a dichotomy between the industrial sector and the primary sectors (oil, mining, agriculture).[4] More recent accounts suggest that the reasons why many argue that natural resources (NRs) cannot spur development are not valid in the current global market and technological context (Pérez, 2010; Marín, Navas and Perez 2015, Andersen, 2015). First, there is an ongoing increase in global demand combined with a diversification in demand requirements. Although at a slower pace than during the 'commodity boom', the expansion in demand of agricultural products is expected to continue at least during the next decade, driven by rapid population growth in Africa and Asia (OCED/FAO 2019).[5] Second, changes in science and technology expanded the production frontier of natural resource-based industries. Advances in biotechnology, nanotechnology, bioelectronics, and new materials, increase the innovative potential of NRs, and make it possible for developing countries to be technologically active in accessing, producing and transforming NRs (Marín, Navas and Perez 2015).

These market and technological conditions create a window of opportunity to use natural resources as a platform to increase innovation and technological capabilities, an idea that gained traction in recent years among scholars and policymakers in Argentina[6] . From this perspective, production and innovation policies should aim to create linkages from sectors like mining and agriculture to knowledge intensive related activities.

The internalization of R&D activities in the local economy is a fundamental prerequisite to promote knowledge intensive activities. This is a major challenge. Middle income countries typically invest a third of what high income countries invest in R&D, and Argentina invests even below the expected amount for its income level (Donner and Schneider 2018:616). Also, while in developed countries the majority of R&D comes from the private sector, in Argentina, as in other Latin American countries, most of it comes from the state (Schneider 2013:65).

This strategy also needs an active role of the state - market signals and incentives are not enough. The past two decades have seen an increasing consensus of the crucial role the state has to play in the process of industrial transformation[7]. Furthermore, historical evidence shows that the use of industrial, trade, and technology policies was the main ingredient of

[4] This framing coincides with policy strategies during the so-called ISI period, when governments distributed excess profits of the agricultural sector towards manufacturing, which was considered to be the only sector capable of achieving gains in productivity, technological dynamism and diversification levels consistent with a process of long-term development (Ocampo and Ross 2011).

[5] Demand of agricultural products is expected to continue to expand in the future (OECD/FAO 2019). Global soybean production, the main agricultural export product in Argentina, is projected to continue to expand at 1.6% annual rate, and Brazil, a strategic market for argentine agricultural inputs, will become the world's largest soybean producer, overtaking the United States. Since the incorporation of arable land has reached a limit globally, increases in food demand will require increased production via technology development while at the same time taking care of the environment (OECD/FAO 2019).

[6] See for example Bisang et al 2011, Marín, Navas and Perez 2015, Schteingart and Coatz 2015, Gerchunoff and Rapetti 2016, Kulfas 2019, Katz 2020

[7] For a review of current consensus towards a ambitious productive development policies and its implications for Argentina see O'Farrell et al (2020)

successful transformation of developed countries (Chang, 2005:106) and developing countries (Evans 1995, Amsden 2001). The next step of this consensus on the role of institutions in industrial policy and human capital is to reach a better understanding of what it takes to build institutions (Donner and Schneider 2018).

In the case of Argentina, the greatest potential for NR-based innovation is in activities related to agriculture, and particularly in agricultural biotechnology (Bisang et al 2011, Marín, Navas and Perez 2015, O'Farrell et al 2021), Biotechnology is a general purpose technology with an increasing variety of applications. It could therefore be targeted by a productive development strategy predicated on promoting backward linkages from agricultural production to knowledge-intensive input sectors. In addition to contributing to diversifying the productive structure, a consolidated biotechnology sector may also generate horizontal spillovers to other economic activities.

Argentina's comparative advantages provide a promising basis for such a strategy. The country is one of the main producers and exporters of agricultural products globally (UNCTAD / FAO, 2017). Commercial grains, for which biotechnology constitutes one of the main inputs, have a significant weight in the country's GDP and export basket. The production of seeds obtained using modern biotechnology techniques represents the largest biotechnology activity in Argentina: with a volume of 1,507 million dollars it represents 70.54% of the total of biotechnology sales (Mincyt 2016). It is also the predominant technology in seeds markets globally: in 2018 the cultivated area of genetically modified seeds 78% in soybean production (95.9 out of 123.5 million hectares), 30% for corn (58.9 out of 197.2 million hectares), 76% for cotton (24.9 of 32.9) and 29% for canola (10.1 of 34.7 million hectares) (O'Farrell et al 2021).

Biotechnology is evolving rapidly and in recent years important advances have been made in the research and development of new techniques, among which gene editing stands out. Gene editing -through its CRISPR Cas9 system[8]- is a new genetic engineering tool with multiple applications in the same fields of transgenesis, but with greater simplicity, security and lower cost (Jouve de la Barreda, 2020). It is widely accepted that the discovery of the CRISPR-Cas9 system has revolutionized plant agricultural research, potentially addressing issues associated with a growing global population, sustainability, climate change and food security (Kuiken and Kuzma 2021, Nature 2021). Since 2010, research publications and patents on gene editing techniques are snowballing (Nature 2021).[9] Because of its relative ease of use, efficiency, and flexibility, it is being implemented in a wide variety of crops to develop several traits of interest (e.g. higher yields, herbicide resistance, drought tolerance, disease resistance, faster growth), with the promise to reduce by half the time it takes to develop an improved trait (Kuiken and Kuzma 2021).[10] A

[8] It allows editing, modifying or deleting specific DNA sequences to alter the expression of specific genes (silencing or overexpressing them) or replacing alleles (introducing favorable alleles). This constitutes a significant advance in modification technologies.

[9] According to the IP Studies database, there are more than 8100 CRISPR patent families worldwide -as of January 30 2021-, 1400 of which are directed to plant agricultural advances involving plant organisms and cells (Kuiken and Kuzma 2021). In 2010, when it was still incipient, 52 articles were counted in SCOPUS. In 2018, after a very important expansion starting in 2013, almost 2,000 documents were related to this topic (Albornoz, 2020).

[10] From 8-12 years with conventional crossbreeding, mutation breeding, or transgenic breeding, down to 4-6 years with CRISPR tools

promising aspect of this technology in terms of the potential to promote local technological capacities, is that the commercial and biosafety regulations do not create a barrier of entry to local firms, as it happened with the transgenesis regulatory framework (Bonny 2017, Feingold et al 2018, Garland 2021).

2. **Diagnose: what is the actual development of local agri-biotech firms?**

For the past three decades the agri-biotechnology sector in Argentina has shown significant dynamism, however, the increase in the number of companies, sales and investment in R&D is concentrated in a few multinational companies and local companies struggle to upgrade technologically. In addition, most of the local companies are small, which represents a problem considering that biotechnology requires large long-term investment projects and high regulatory costs. With the support of the public STI system, some local companies patented developments -like the HB4 technology of Bioceres- that compete on the technological frontier, but these are more an exception than the rule (O'Farrell et al 2021).

These trends reflect the transformations of the agricultural input sector globally. The introduction of genetic engineering techniques, particularly transgenesis, combined with the changes to intellectual property rules that enabled transgenic gene sequences to be patented, resulted in the consolidation of a biotechnology sector in a few MNCs, most of them originally from the chemical sector (Sell, 2009; Bonny, 2017; Clapp, 2018). In 2013 only 6 firms -Syngenta, Bayer, BASF, Dow, Monsanto y DuPont- controlled 59.8% of the global seed market and 76% of agrochemicals. They also accumulated 76% of all private investment in R&D of those two activities (ETC Group 2013). Since 2015, sectoral concentration has deepened as a result of a fast process of mergers and acquisitions that reduced the number of leading firms from 6 to 4 (Bayer-Monsanto, Syngenta-ChemChina, Dow/Dupont and BASF) (Clapp 2018).

Many analysts warn that the combination of market concentration and proliferation of patents, particularly patents over research tools, may be disincentivizing innovation and knowledge dissemination in agribiotechnology and seeds production, since it entails a barrier for start-ups and inhibits public R&D (UNCTAD, 2006; Sell, 2009; Marín et. al., 2015; Anlló et. al., 2016). This problem is clearly aggravated when companies use their portfolio of licenses and patents to harm their competitors, instead of using them for its actual objective of protecting their technology. Companies may decide not to license or ask for unreasonable terms and try to block their technologies' applications in order to damage their competitors (Sell, 2009). In the case of agricultural biotechnology, the multiplication of patents on techniques, technologies and genes can result in a blocking access that prevents any new variety from developing (Marín and Stubrin, 2017).

Local adaptation of international regulations and standards play a significant role for countries aiming to upgrade to more technologically intensive or profitable segments of the agricultural GVC. In this sense, an advantage of the patent landscape of gene editing techniques is that, unusually, it is dominated by universities and publicly funded research organizations, with only one third in hands of the private sector (Nature 2021). This fact raises expectations about the possibility of more technology diffusion than with the transgenesis patent families, which are largely concentrated in a few MNCs.[11]

In Argentina, since the 1990s input provision became increasingly concentrated and denationalized, while technology implemented exogenously became a key to sustaining competitiveness of agriculture (Bisang et al 2010, Anlló, Bisang, and Campi 2013). After the introduction of biotechnology, the structure of the seed market can be simplified in two types of firms: biotechnology companies and traditional seed breeding companies. Biotechnology companies develop transgenic traits that make seeds resistant to particular herbicides or pests. Biotechnology firms grant the transgenic traits under commercial licenses to seed companies that develop seed varieties through genetic improvements using traditional breeding methods combined with other modern biotechnology techniques.

Local companies encounter significant obstacles when it comes to upgrading in the agricultural biotechnology value chain. As a matter of fact, the innovation process in Argentina shows a clear division of labor between multinational and local firms (Marin and Stubrin 2017). The former controls the most profitable link in the value chain - the development of transgenic events -, which remains beyond reach for local firms due to its high regulatory costs. Conservative estimates suggest that the cost of patenting and deregulating transgenic events can be around 80% of the cost of developing the event (Sztulwark 2012).[12]

The dominance of MNCs is clearly evidenced in the patenting of transgenic seeds: there are only 3 entirely local developments out of 62 transgenic events commercially approved between 1996 and 2020. One is property of Tecnoplant and two of Bioceres-INDEAR and the three of them have been developed in the public science and technology system (O'Farrell et al 2021).

Local companies have been able to take hold in the development of new varieties of plants and seeds and play a key role in the adaptation of seeds to local agronomic conditions by using other modern biotechnological techniques, such as molecular markers, bioinformatics and mutagenesis. In effect, local firms have registered 2107 new varieties of seeds out of 4011 between 1996-2020 (including soybeans, wheat, sunflower, and maize), a participation of 53.30%.

The most competitive of the local seed and biotech companies with potential to upgrade in the biotechnology segment are ACA, Bioceres-INDEAR, Grupo Don Mario, Status Ager and Gensus SA. With the emergence of genetic editing new possibilities arise for local start ups,

[11] In september 2021 Nature published an editorial calling for "all universities that hold CRISPR patents, along with public funders and international institutions such as the World Intellectual Property Organization, to consider how they might join forces so that IP on CRISPR can be more easily accessed free of charge for research, under clear and transparent rules." (Nature 2021)

[12] Accoridng to sztuwark (2012) the cost of developing a GM crop can be around 19 million dollars (I+D (evento transgénico): u$s 10.000.000, Introgresión (genética de elite): u$s 800.000, Costos Regulatorios: u$s 8.000.000, Protección de la PI: u$s 200.000). These regulatory costs of transgenesis act as an entry barrier for local companies and partly explain the control of the market by multinational companies. Despite having a significant level of technological capabilities, local companies are at a disadvantage compared to multinational companies in terms of financial and legal resources necessary to face the processes of deregulation and defense of intellectual property of their products (Marín and Stubrin, 2017).

like is the case of R&D firm Bioheuris, the first local firm to sign in 2018 licensing agreements to access CRISPR technologies (Bagley 2021).

As argued in the following sections, low appropriation of technological rents is hindering the capacity of local companies to strengthen R&D and productive capacities and compete for spaces in the most profitable segments of agricultural biotechnology.

3. What are the policies and regulations affecting this result?

As a science based activity, biotechnology is intensive in R&D spending. The evidence on the development of biotechnology companies -in Argentina and globally- shows that the scientific-technological system is a determining source of the innovation performance (O'Farrell et al 2021)[13]. STI capacities in biotechnology are determined by human, financial and infrastructure resources, and by the trajectory and knowledge accumulation in related sciences such as molecular biology, genetics, and agricultural sciences, among others.

From this starting point, in this section I argue that low public and private investments in R&D are holding back local technological and productive capabilities in agricultural biotechnology.[14]

3.1. Low public R&D in agricultural biotechnology

In this subsection I provide data on public R&D and public scientific resources on agricultural biotechnology. I argue that despite being at low levels compared to countries with similar GDP per capita levels, agriculture and biotechnology have an important proportion of total R&D and played a significant role in the promotion of local agri-biotech firms. The exceptional cases of local firms competing in the development of transgenic traits managed to do so in articulation with public research institutes and support of public STI subsidies.

Argentina invests 0.55% of GDP in promoting science and technology activities, a level that is above that of other countries in the region such as Chile, Colombia and Mexico, but well below the level of the average for the OECD, which stands at 2.39% of GDP (OECD 2019).

Agricultural innovation is an important chapter of science, technology and innovation (ST&I) policies in Argentina, reflecting the importance of the sector in economy (OECD, 2018). The research intensity of agriculture in Argentina is similar to that of Chile, but significantly lower than in the United States or Brazil. Despite the organizational innovations that have provided new roles for new private actors, R&D expenditure is mainly public. Another problema is that the system needs to be more responsive to demand and less supply-driven (OECD 2018).

Biotechnology has also received a significant proportion of public R&D efforts. The public system has 2950 researchers and 1051 projects dedicated to biotechnology, 37% of them to agricultural biotechnology. Most of the research groups and professionals dedicated to biotechnology work in the university system, the institutes of CONICET and INTA. There are

[13] VER: Coriat, B. Orsi, F. y Weinstein, O. (2003). Does biotech reflect a new science based innovation regime? Industry and Innovation, 10(3), septiembre.

[14] Certainly, investment in R&D has to be complemented with policies to strengthen systemic aspects of innovation, like for example instruments for technology transfer and more generally to improve the quality of linkages between actors in the system (for an analysis of agribiotech innovation in Argentina through a sectorial systemic perspective see O'Farrell et al 2021).

86 centers and laboratories that carry out R&D in biosciences and biotechnology. However, the important number of scientists and public and private institutions working on biotechnology did not conform to a network with impact on the productive phase (Anlló et al 2016).

Most of the public technological capabilities in seed development are at INTA, the national institute for agricultural technology. Until the 1990s, INTA was a prominent actor in agricultural biotechnology, central in the provision of technological developments in genetics for the seed industry (Marín and Stubrin, 2017). Since then, a process of divestment and institutional deterioration at INTA combined with the analysed expansion of MNCs have deepened the privatization of seed technological development (Amin Filomeno, 2013; Gras and Hernández 2016; Regunaga, 2009). One of the key reforms undermining state capabilities was the elimination of export duties in 1995, depriving INTA of the financing that until then had been assigned by law. The loss of financial autonomy weakened the capabilities of the institute, which lost a large part of the technical staff (Amin Filomeno, 2013). With less resources INTA shifted towards efforts on issues related to small scale agriculture and let large scale export crops to private technical associations and MNCs. This deterioration is reflected very clearly in the difference in the performance of INTA with the Brazilian agricultural technology institute, Embrapa, in terms of seed development and patenting of genetically modified organisms (GMOs) (Amin and Filomeno 2013). In the early 2000s, INTA began to recover instruments and resources, with a sustained increase in funds and the incorporation of staff. In particular, since 2008 there has been a growth in the budget that almost tripled the historical average. With some fluctuations, it continued to increase in real terms until reaching its peak in 2016, after which it decreased again.

According to a study published by the OECD (2018) a limitation comes from its highly decentralized structure, which contributes to weak linkages among the different components and, often, to the image of overlapping and disjointed efforts. In order to keep its capacity to contribute to the innovation process, the institute needs a more strategic direction and a prioritization of its objectives based on impact assessment and new demands (OECD 2018). According to directors at INTA interviewed for this project the lack of resources are hindering INTA's capacity to sign licencing agreements to access gene editing technologies.[15]

Despite the identified weaknesses, public investment in R&D contributed decisively to the development of local agri biotech firms. As pointed out before, public STI efforts have been a determinant feature of the successful performance and growth of Bioceres, the only local firm that managed to compete in the MNC-dominated business of transgenic traits. This challenges prevailing media accounts of the expansion of Bioceres as a market-driven success. The firm was very effective in creating linkages with the public science and technology system and to access public subsidies for science and technology promotion. Central in Bioceres' portfolio is the development of the HB4 technology, a result of more than 15 years of public-private collaboration between the company and a group of Argentine molecular biologists and researchers.[16] This technology is a set of two transgenic events designed for soybean and wheat crops that allows obtaining seeds with greater tolerance to droughts, a feature of vital importance in the context of climate change and the increasing

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[15] Not for attribution interview with Director at INTA (20 october 2021).

[16] The project was led by researcher Dr. Raquel Chan, Director of the Instituto de Agribiotecnología del Litoral (IAL, CONICET-UNL)

occurrence of droughts.[17] The other most valuable product owned by Bioceres Group was also developed in the public STI system - Rizoderma, a biological fertilizer developed by INTA and scaled by the firm Rizobacter[18].

In addition to the critical role of researchers from INTA and CONICET, Bioceres-INDEAR received determinant financial support through public subsidies administered by the National Agency for Science and Technology promotion (Agencia I+D+i), particularly by the Argentine Technological Fund (FONTAR, in its Spanish acronym). FONTAR is a sectoral fund that finances technological innovation projects aimed at improving the private sector productivity and has played a crucial role in the seed varieties developed by INDEAR. According to a sample of 526 beneficiaries of FONTAR between 2003 and 2008, 10% of the subsidies were allocated to the agricultural sector and 87% of these were assigned to INDEAR[19] (Peirano, 2011).

3.2. Low private R&D

As one of the largest markets of genetically engineered seeds, Argentina attracted investments of all the leading global players in agricultural biotechnology. Since the 1990s companies like Pioneer, Monsanto, DuPont and Syngenta expanded their activities in the country, as well as their investments in R&D. Between 1990 and 2014, investment in R&D multiplied by three in real terms, with most of this increase occurring after 2004 (Stubrin 2019).

However, private investment in R&D in biotechnology is still at very low levels and MNCs invest a very small fraction of their R&D efforts in Argentina. The last available estimation is that in 2014 investment by agri biotech companies amounted to 58 million usd. This represents 1.1% of global investments in R&D in biotechnology activities, which the same year ascended to 5,357 million usd (Fuglie, 2016). An important aspect -and increasingly problematic in terms of knowledge diffusion- is that this spending is highly concentrated in a few firms: in 2013 Monsanto invested 1,533 million usd and Syngenta 1,379 million usd. (Statista, 2016). This confirms a more general trend - MNCs prefer to keep their R&D activities in their home countries. It also reveals a harsh truth - if local firms and public institutions do not make the necessary R&D efforts, the potential contribution of biotechnology to productive diversification will most probably vanish.

3.3. How does the intellectual property framework affect the appropriation of innovation rents in seed technologies?

[17] The development, the first of its kind worldwide, improves the adaptability of plants to situations of water stress, thus giving greater predictability to yields per hectare and minimizing production losses. HB4 technology has faced many regulatory challenges that blocked its commercialization. Even though both soybean and wheat HB4 technologies have been approved by CONABIA and SENASA - Argentina well-reputed public organisms in charge of assessing the agroecosystem, food, productive and commercial safety of proposed genetically modified organisms -, as well as by United States, Brazil, Canada and Paraguay, the Agricultural Markets Directorate of Argentina postponed the dissemination of these technologies until China also approves the soybean HB4 technology and Brazil the wheat one.

[18] For an account of this development see O'Farrell et al (2021)

[19] In monetary terms, since the total transfers by FONTAR between 2003 and 2008 amounted to 26 million dollars, we estimate that INDEAR received 2.26 million dollars. Alternative estimations suggest the total amount goes up to 8 million dollars. Not for attribution interview with researcher that accessed FONTAR's database.

As with other knowledge-intensive products, the regulation of intellectual property of seeds is a highly contested area. The main stakeholders interested in the rules of control and use of knowledge around seeds are agricultural producers (users of the technology), biotechnology companies (developers/owners of patentable transgenes), seed companies (improvements in germplasm) and public laboratories and research institutions (R&D).

Here I argue that low private R&D is a consequence of the intellectual property regime in seeds and biotechnology. The Argentine intellectual property regime has asymmetrical consequences for appropriation of the biotechnological innovation rents, which tend to be especially detrimental for local technological capabilities. The current regime, formed by a mix of intellectual property legislation, private contracts and commercial practices- favours MNC biotech companies and large agricultural producers over local seed and biotech firms and public research institutions. Three important and problematic features in this respect are: (1) the distortion of the right of agricultural producers to reutilize seeds (2) the dimension of the ilegal seed market, and (3) the imbalance and inconsistencies between the Seeds Law and the Patent Law.

1. *Distortion of the right of agricultural producers to reutilize seeds:* One crucial aspect of the seed IPR framework is the right -established by the Seeds and Plant Genetic Creations Law No. 20247 of 1973[20]- for producers to reuse seeds without paying royalties to the supplier. As self-pollinating species, soy and wheat seeds maintain yield levels in successive generations. This is why producers are able to save the production and use the seeds in future campaigns. This facilitates a significant transfer of rents from seed and biotech companies to agricultural producers which, in the case of soybean, are mainly big agricultural companies that manage large tracts of productive land. A fundamental aspect of this result of the distribution of technological income is that most of it is appropriated by large agricultural companies, which are the ones that concentrate most of the agricultural production in Argentina. These large companies are far from the profile of agricultural producer that the Seed Law of 1973 tries to protect with the right to reuse seeds without paying royalties (Linzer, 2016). That article of the law is included to protect farmers that contribute with positive externalities in terms of social, territorial and environmental development and this applies mostly to small agricultural producers.

2. *The extension of the ilegal seed market.* The right to reuse seeds, combined with lax state controls, has facilitated the expansion of an extensive (and illegal) market for non-certified seed, known as the 'white bag' (bolsa blanca), which is widespread in soy and wheat seeds commercialization. It is estimated that only 36% of soy production and 44% of wheat is certified seed, that is, directly bought from the seed company or reused but recognizing intellectual property and paying royalties (ASA-UBATEC 2017) and that in 1996 this percentage in soy was approximately 50% (O'Farrell, 2020)[21]. This represents a significant difference to other similar soy

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[20] Framed within the international guidelines established by the UPOV 1978 system. The most widespread sui generis system in countries for the protection of plants is the UPOV Agreement. There are two systems currently in force: UPOV 1978 and UPOV 1991. The latter is more similar to the patent system. Among developing countries UPOV 1978 still predominates, however, there is enormous pressure from advanced countries and multinational companies to move in the direction of UPOV 1991 (Marin and Stubrin, 2017).

[21] The rest is partly seed that producers save and replant, and partly seed bought in the illegal market.

producing countries: estimates suggest that in Brazil certified seed represents 75% and in Uruguay 95%[22]. This has been a problem for seed breeding companies, and according to a survey among seed companies it has negatively affected R&D efforts (ASA-UBATEC 2017). It also explains the limited presence of multinationals in the soy and wheat seed business compared to other crops (O'Farrell, 2020).

An important difference between local firms and MNCs developing transgenic traits is that the latter managed to implement a private system of royalty collection. As analysed in the next item, transgenic traits are protected by the Patent Law. Thanks to this stricter IPR protection, as in other countries, owners of the patents (biotech firms like Monsanto) implemented private royalty collection systems by signing contracts with agricultural producers in which the latter renounced their right to reuse seeds without paying royalties.

3. *The imbalance and inconsistencies between the Seed Law and the Patent Law*. Different to seeds, transgenic traits are covered by the stricter intellectual property framework established by the Patent Law, which overlaps with the Seed Law in regulating the same matter. Although both refer to the same thing (the seed), the Seed Law applies to varieties of plants (i.e., improvements in germplasm) while the Patent Law applies to genes (i.e., improvements obtained using genetic engineering such as transgenesis). This creates an inconsistency: even though the seeds cannot be patented, with a patented transgene the intellectual property of transgenic seed varieties remains, in practice, regulated by the Patent Law (Arza, 2014). The resulting regulatory framing, a combination of public and private institutional arrangement that coexist with informality, is a pattern of appropriation of innovation rents that favors multinational companies that develop transgenics over the rest of the seed companies. Some estimates indicate that with this scheme, Monsanto is guaranteeing the appropriation of 66% of the total price of the sale of each bag of seeds that have the Monsanto gene, which leaves the remaining 33% to be distributed among Argentine germplasm companies (like Don Mario) and multipliers (Marín 2015, cited in Linzer 2016).

   Companies that develop germplasm, mostly small and medium-sized national companies, are at a disadvantage when compared with firms, mainly multinational, that develop transgenics and own patentable genes (Lowenstein 2014, Linzer, 2016; Marin and Sturbin, 2017, O'Farrell et al 2021). Such an imbalance between the owner of a plant variety and the owner of a gene implies that the former cannot have access to the gene protected by a patent without a license, while the latter can legally access the plant variety with fewer and less restrictive conditions. This put domestic seed firms in a subordinate position vis-a-vis the MNCs companies that own the transgenic events. They depend on license contracts to access key technologies demanded by producers, which tends to reproduce a hierarchical relation among them. Although it is beyond the scope of this paper, this imbalance should be addressed by a reform of the Law of Seeds.

[22] Bertello (2015) https://www.lanacion.com.ar/economia/campo/bolsa-blanca-un-ilicito-sin-control-que-desacopla-ala-argentina-de-la-region-nid1783187/

4. Proposal: National Innovation Fund for agricultural biotechnology

The previous sections suggest that, in order to promote innovative local agri-biotechnology companies, it is necessary to increase private and public R&D and that to do this we need to reform rules affecting the distribution of technological rents. In other words, it is necessary to rethink how to increase the appropriation of innovation rents but also how these rents are distributed and reinvested. The sole increase in the capture of technological rents without establishing clearly how it is distributed, will most likely benefit only the patent owners and developers of transgenic crops, deepening the already high levels of concentration described in the previous sections of this paper (Correa, 2014; Linzer, 2016).

The proposal of this paper is to create a National Agri-biotechnology Fund to strengthen local technological and innovation capabilities and finance a national agri-biotechnology development strategy. In order to do this the Fund will increase the appropriation of innovation rents by seed and agricultural biotechnology developers and rebalance their distribution. The aim is to redistribute from large agricultural producers and biotech companies that develop transgenic events to public research institutes and national seed and biotech firms that use biotechnologies other than transgenesis. The formation of the fund should complement and not replace current initiatives and resources of the National Agency for R&D (Agencia I+D+i).

I present two alternative proposals based on previous projects designed by researchers and authorities at INASE and INTA. The common aspect of the two alternatives is that they aim to incentivize the purchase of certified seed and better compensate local seed and biotech firms and increase public resources for public R&D as part of a national strategy.

Alternative 1 (keeps right to reuse seeds without paying royalties; no distinction between type of producer)[23]

The first alternative establishes that all agricultural producers should pay a “technological fee” at the moment they sell their harvest of soy, wheat and maize.

- The rate varies between 0,7% and 1,90% on the value of the harvest, depending on the species.
- The buyers (which may be cooperatives, traders, intermediaries, processors/mills) withhold the corresponding amount and transfer it to a specific account created for the National Agri-biotechnology Fund.
- Agricultural producers that can prove that their production comes from certified (legal) seed *or seed legally multiplied*, receive back the same amount they paid.
- Agricultural producers that cannot prove that they used certified seeds are not attributed and receive an economic sanction (by the terms established in the corresponding article of the Law of Seeds).

Alternative 2 (discriminating by type of producer on the right to reuse seeds without paying royalties)[24]

[23] Based in Costamagna (2004) and INTA (2016)
[24] Based in Linzer (2016)

- For small agricultural producers the system is the same as in alternative 1. If they can certify that they purchased certified seed they receive back the same amount, if not they are sanctioned.

- In the case of medium and large producers, the main difference is that they have to pay the "technological canon" also if they reutilize seeds, i.e. they only receive back the paid amount if they can certify that they purchased certified seed *that same season* but do not receive it back if their production comes from reutilization of certified seed. Plus, If they cannot prove they purchased certified seed *that same season* they also receive an economic sanction.

- *Definition of large producer*: Official reports and resolutions consider that a small producers of soy, wheat, and corn manage less than 1000 tonnes or up to 700 hectares (Minagri 2015 cited in Linzer 2016). In 2014, there were 46.121 producers in that segment, representing 69% of producers but only 12% of total production. Above the 700 hectares threshold there were 20.721 producers, representing 31% of producers and 88% of total production.

- *Distribution of the Fund:* The Fund should be distributed in three tranches (in both alternatives):

    - T1. Compensate seed companies that developed and registered that seed variety,

    - T2. Return the deducted amount to agricultural producers that proved they used certified seeds,

    - T3. Finance seed and biotech R&D activities that contribute to varieties of relevance for the country. Directed to public research institutes in agricultural biotechnology and provide subsidies for national seed and biotech firms.

- *About the rate*: The rates of 0,7%-1,9% are moderate compared to the 15 dollars per ton that Monsanto established for its private royalty collection system[25], but above the levels suggested in the proposal by Oscar Costamagna from INASE in 2004. The criteria is to raise enough to provide an incentive to buy certify seed, compensate seed breeders and producers that buy certify seed, and finance tranch number 3 of the Fund.[26]

- *Expected revenue*: the expected revenue is 135 million dollars. This is a larger amount than INTA's annual budget.

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[25] Schvarzer and Tavosnaska (2007) calculated that what Monsanto claimed for royalties from RR technology ranged from 100 to 150 million dollars per year and add that instead of concentrating on multinational companies that import technologies developed in their countries of origin, part of these funds could be used to finance "a special institute for the development of new agricultural varieties larger than INTA and that could have a substantive effect on the advancement of Argentine competitiveness in these areas" (Schvarzer and Tavosnaska, 2007: 41).

[26] According to Linzer (2016) in 2014 the difference between certified soy seeds and black market ones was of 27 usd vs 18 usd, so a 9 usd fee would be incentive enough. Depending on the year that could represent approximately a 2% rate.

- *Alternative 1 vs Alternative 2*: Alternative 2 is more effective in eliminating the analysed distortion of the Seed Law in relation to the right to reutilice seeds without paying royalties. In alternative 2 the right to reuse seeds still exists also for large and medium producers but it becomes onerous (uso propio oneroso). With alternative 1 a large part of the revenue of the Fund goes back to large agricultural producers, diminishing the potential impact of the fund in terms of promoting public research and local start ups.

Governance

In order to better coordinate public efforts in R&D, the distribution of T3 of the Fund should be part of a national strategy implemented by a Council for Agricultural Biotechnology formed. This Council should be formed by an inter-ministerial body (including directors at INTA, INASE, Mincyt, Agencia I+D+i, Ministry of Agriculture, Ministry of Production, Ministry of Environment); private sector representatives from agriculture, seed and biotech sectors, and civil society organisations. This differs from previous proposals that stated INASE should be the institutional authority in charge of administering the Fund,

This is justified in previous studies that suggest that one of the challenges of innovation in agricultural biotechnology (O'Farrell et al 2021, OECD 2018) and pharmaceutical biotechnology (Marín et al 2021) in Argentina is the lack of coordination between different public and private actors and organizations engaged in its development. Even though Argentina proved to have interesting scientific-technological capabilities, it had felt short in the crucial aspect of promoting public-private articulation and to coordinate with other crucial areas like for example regulatory bodies in charge of commercial approval of technologies (O'Farrell et al 2021).

To overcome these challenges, the Council should be responsible to promote technology transfer mechanisms, support firms in building alliances to access to new knowledge and technologies, transform their technical knowledge into commercial products, identify niches and access new markets. More generally, it should aim to strengthen linkages and coordination between the S&T system (and its policies) and the requirements of the productive sector. This means that parts of the Fund should be assigned to strengthen IP and technology transfer capacities of the scientific sector, commercialization, marketing, etc. Also, among other responsibilities, this body should establish clear guidelines and mechanisms through which the state is retributed for its investments.

The need for an inter-ministerial public-private body is also justified in the complex political economy of agricultural biotechnology. Multiple and often contradictory interests between public and private actors involved in the agri biotech value chain is one of the factors holding the sector back. This type of institution can help to find common grounds between previously antagonic actors and provide a space for deliberation and strategizing. The example of Bioceres can help as a guide of effective public-private articulation.

The criteria for the distribution of the Fund's resources should incorporate a clear assessment and selection of strategic technologies and products. This should be sensible to the actual and future challenges to agriculture in Argentina and elsewhere, from climate change to biodiversity loss, from productivity to social development. Recent experience suggests that it is highly unlikely that market driven technological change will provide an efficient solution to the diverse challenges identified (O'Farrell et al 2021). Agricultural biotechnology will help to navigate some of these challenges only if its promotion is part of a national strategy that promotes certain technologies according to specific priorities.

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