



Is GM Soybean Cultivation in Argentina Sustainable?

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Summary. — This paper explores the long-term sustainability of Argentina's specialization in genetically modified (GM) soybean cultivation. We perform an evidence-based assessment of the most relevant economic, social, and environmental implications of the “soybeanization” of Argentinian agriculture. Our diagnostic relies on a combination of published sources and a unique data set drawn from a field survey carried out in 2011 in two provinces of the Argentinian Pampas. This data set allows us to evaluate with a reliable empirical base the socio-economic impacts of GM soybean cultivation. Our analysis suggests a conflict between the success of the “soybeanization” of Argentinian agriculture measured in terms of production and profit records, and the social, economic, and environmental sustainability of this new model of production. On the one hand, GM soybean technological package adoption has increased farm productivity, and reduced the costs per unit produced, resulting in a dramatic increase in profits. On the other hand, the specialization of Argentinian agriculture on soybean cultivation has increased the dependence of public finances on the foreign exchange revenue generated by exports earnings. We also find a mixed empirical picture of changing land distribution patterns and labor displacement resulting from GM soybean expansion. Finally, we find that the environmental implications of agricultural biotechnology appear alarming and the long-term sustainability of GM crops highly questionable. Promoting sustainable agricultural growth has become not only desirable but necessary.

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1. INTRODUCTION

Agriculture has long been a central engine of Argentina's economy. The country has a significant natural comparative advantage for the production of many agricultural products: 33.5 million hectares of arable land, deep and fertile soils, fairly regular rainfall, and direct access to the sea. In 2014, the agro-food sector generated 17.6% of Argentina's Gross Domestic Product (GDP) while processed agricultural and livestock products accounted for 62% of total exports.¹

The transgenic Roundup Ready (RR) soybean was introduced in Argentina in 1996 and since then has been so rapidly adopted that Argentina is now the most intensive user of biotech seeds in the world. The technological package consists of a genetically modified soy variety resistant to the herbicide glyphosate and sold under the commercial name of Roundup, and complementary technologies such as direct seeding (soil is not tilled before planting), chemical nutrition of the plant, and heavy mechanization of agricultural operations. The direct seeding technique limits soil disturbance and preserves soil moisture, and the use of the glyphosate herbicide simplifies weed control activities. Chemical fertilization is expected to improve yields, while mechanization reduces the work involved in cultivation. All of these components have made crop production more efficient.

Between 1996 and 2016, GM soybean production increased at an average rate of 3.1% a year, mainly at the expense of cattle production, and competing summer crops such as maize, sunflower, and wheat. During the last agricultural season (2015–16), genetically modified (GM) soybeans were cultivated on nearly 20.5 million hectares, which represented 60% of total land cultivated, and production reached a record 61 million tons. The oilseeds sector has thus gradually become a strategic sector of Argentina's economy, generating a large trade surplus and foreign exchange resources. It has supported economic growth and contributed in a major way to restoring the macro-economic fiscal balance after Argentina's severe

economic depression of 1998–2002. In 2015, the soybean sector accounted for 30.7% of total exports of the country. In the same year, Argentina dominated the international soybean pellets market with nearly 33.3% of world exports, ahead of the United States and Brazil.

The dramatic productive performance of GM soybean cultivation has been triggered by deep technical and organizational changes, summarized in the expression “*el modelo sojero*” (the soybean model). This model consists of intensive, large-scale, mechanized production, and very efficient management of farming operations based on new forms of association between farmers known as “sowing pools”, that lease services to specialized firms for the main farming operations (Hernandez, 2009).

However, the social and environmental implications of biotechnological agriculture have recently become a source of concern, and its long-term sustainability seriously questioned (Alabaldejo & De Sartre, 2012; Bouza *et al.*, 2016; Carreño, Frank, & Viglizzo, 2012; de la Fuente, Suárez, & Ghera, 2006; Gavier-Pizarro *et al.*, 2012; Leguizamón, 2013).

Among the negative socio-economic effects most often cited are corporate dominance, land concentration, loss of farm jobs, and an increase in income inequality, although these issues are not well documented. Harmful environmental impacts which have been highlighted in the literature include land use change, from forest or pasture to cultivated land, excessive use of chemical inputs, which contaminates soils and groundwater, destruction of ecosystems, and erosion of biodiversity (Bouza *et al.*, 2016; Gavier-Pizarro *et al.*, 2012; Pengué, 2005). The emergence of health problems such as res-

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piratory illnesses or high incidences of cancer resulting from aerial spraying of pesticides have also been reported (Arancibia, 2013; Gallegos *et al.*, 2016).

This paper explores the long-term sustainability of Argentina's specialization in GM soybean production. Because sustainability is a very multidimensional concept, this paper is conceived as an evidence-based assessment of the most relevant economic, social, and environmental implications of the "soybeanization" of Argentinian agriculture. Our contribution is twofold. First, our results are based on a unique data set drawn from a field survey carried out in 2011 in two provinces of the Argentinian Pampas. This data set allows us to evaluate with a reliable empirical database the socio-economic impacts of GM soybean cultivation. Second, we adopt a holistic approach by addressing all facets of sustainability. To our knowledge, this comprehensive work has never been done before. Our results suggest a conflict between the success of the "soybeanization" of Argentinian agriculture measured in terms of production and profit records, and the social, economic, and environmental sustainability of this new model of production.

The rest of the paper is organized as follows. Section 2 discusses the concept of sustainability in agriculture in order to lay the foundations for the succeeding sections. Sections 3–5 investigate the economic, environmental and social sustainability of GM soybean production. Section 6 discusses the results and policy implications.

2. WHAT IS SUSTAINABILITY IN AGRICULTURE?

Sustainable agriculture is a multifaceted concept for which Pretty (1995) acknowledges the difficulty of defining. While several definitions have been proposed over time in the literature (Pretty, 2008), the multiplicity of definitions put forth makes a single definition difficult to use and implement.² Defining the sustainability of agriculture is all the more difficult due to its multifunctionality.³ Although sustainability and multifunctionality are two different concepts in the sense that multifunctionality is a characteristic of agricultural systems, whereas sustainability is a goal to achieve (OECD, 2001), their interconnection intensifies the difficulty in providing a clear and useful definition of sustainable agriculture.

The following attempts have been made "Agricultural technologies and practices that: (i) do not have adverse effects on the environment (partly because the environment is an important asset for farming), (ii) are accessible to, and effective for, farmers, and (iii) lead to both improvements in food productivity and have positive side effects on environmental goods and services. Sustainability in agricultural systems incorporates concepts of both resilience (the capacity of systems to buffer shocks and stresses) and persistence (the capacity of systems to continue over long periods), and addresses many wider economic, social and environmental outcomes" (Pretty, 2008, p. 1);—or "An integrated system of plant and animal production practices having a site specific application that will, over the long term: (a) satisfy human food and fiber needs; (b) enhance environmental quality; (c) make efficient use of non-renewable resources and on-farm resources and integrate appropriate natural biological cycles and controls; (d) sustain the economic viability of farm operations; and (e) enhance the quality of life for farmers and society as a whole" (1990 U.S. Farm Bill in Velten *et al.*, 2015, p. 2). Other definitions have been provided at the farm level: "For a farm to be sustainable, it must produce adequate amounts of high-quality food, protect its resources and be both environmentally safe and prof-

itable. Instead of depending on purchased materials such as fertilizers, a sustainable farm relies as much as possible on beneficial natural processes and renewable resources drawn from the farm itself" (Reganold, Papendick, & Parr, 1990 in Velten *et al.*, 2015, p. 2).

To summarize, these definitions focus on an agriculture that meets human needs, today and for future generations, limits negative impact on natural resources, is economically durable and socially acceptable. Our analysis aims to capture different social, economic, and ecological parameters, and to cover both the macro and micro (farm) levels. At first sight, trade-offs seem to exist between sustainable agriculture and productivity, which challenges the compatibility between these pillars of sustainable development (OECD, 2008; Pretty, 2008).

In the case of GM soybean cultivation, the trade-offs are especially challenging given, on the one hand, its high profitability and its contribution to the Argentinian economy, and on the other hand, its pressure on natural resources. Therefore, in the subsequent sections, we thoroughly investigate every facet of GM soybean cultivation in Argentina in order to assess its sustainability, taking into account three dimensions: economic, social and environmental. There are several points of contention about the sustainability criteria for Argentinian agriculture. Does GM soybean cultivation have adverse environmental impacts? Does it minimize pressure on resources and harm to human health? Does it contribute positively to the Argentinian economy? Does it favor social cohesion and farmers' livelihoods? It goes without saying that the answers to these questions are not unequivocal, which we will discuss in the following sections.

3. ECONOMIC SUSTAINABILITY

In order to assess the long-term economic sustainability of GM soybean production, both the micro (farm) and macro levels must be considered.

(a) *At the farm level*

At the micro-economic level, private profitability ultimately determines whether producing GM soybeans will be considered "sustainable" by Argentinian farmers. Most studies have found positive economic returns for the adoption of GM soybean cultivation in Argentina, and many authors indicate on average 20 USD per hectare in cost savings compared to conventional soybean cultivation (Craviotti & Gras, 2006; Qaim & Traxler, 2005; Trigo & Cap, 2004). Ten percent gains in total productivity have been reported, as well as the fact that, in terms of aggregate welfare, 90% of the economic surplus created by the crop is captured by producers (Qaim & Traxler, 2005). This is confirmed in two recent meta-analyses (Finger *et al.*, 2011; Klümper & Qaim, 2014) which stress the superior economic performance of GM over non-GM crop cultivation.

The main benefit of GM technology is a better cultivation process, which results in higher yields, and big reductions in operating costs. Better crop yields arise mainly from the spreading of glyphosate, which facilitates weed management, and considerably reduces crop losses related to weed infestation. Savings in operating costs result from mechanization of all farming operations, which saves producers time performing daily tasks, reduces farm labor requirements by about 30%, and simplifies the management of cultivation operations.

In addition, GM seeds and glyphosate are available at low prices due to the inability of Monsanto to patent its innova-

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