



# Rural development and environmental protection through the use of biofertilizers in agriculture: An alternative for underdeveloped countries?



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## ARTICLE INFO

### Article history:

Received 6 November 2015

Received in revised form

21 April 2016

Accepted 4 June 2016

### Keywords:

Biotechnology

Agriculture

Economy

Rural development

Environmental protection

## ABSTRACT

Economic momentum of underdeveloped countries derived from the generation and application of their endogenous knowledge is an essential factor toward achieving social welfare. Thus, it is important to understand the development of science and technology within these underdeveloped countries, how the application of that development can address problems in agriculture and food needs, and how that development can offer sustainable options for growth and optimization. In addition, many small farmers in underdeveloped countries are already planting crops based on biotechnological products, which is significant in terms of how these activities influence the development of their lives, particularly with respect to the generation of policies aimed at farming areas. This paper is an exploratory study on the perceptions of peasant producers of the effects of biofertilizers on their environment and their lives. This research is based on a study of peasant producers of the State of Morelos, Mexico, who use biofertilizers produced from endogenous technological assets, i.e., that involve private actors and public research centers. The results facilitate understanding the perceptions of these peasants in addition to the challenges and opportunities that rural areas face and the connections between the involvement of business, academia and government in planning and administration with respect to the management of these innovations.

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## 1. Introduction

Since ancient times, biotechnology has been used to attend the needs of the population. Biotechnology is defined as a science that offers technological solutions from biological organisms, systems and processes related to them, which creates a whole industry in areas such as food, agriculture, and health, among others, and in which the use of technologies employed varies from one application to another in an important manner. Such solutions relate to techniques that go from using fermentation processes to integrating recombinant DNA technology [1–3].

A case study was performed to investigate the effects that endogenously generated technologies have had on the environment and on the lives of the peasant producers who use them. In addition, the challenges and opportunities that lie ahead for the rural environment, business, academia and the government with respect to policy planning and administration for the proper use of these innovations are identified. Specifically, the case for biofertilizers in the area of agricultural biotechnology is affirmed.

To improve understanding of the problem, two theoretical sections are developed. These sections aim to explain, on the one hand, how the theory of development and agriculture is constrained in underdeveloped countries and, on the other hand, how the relationship between technology, agriculture and environmental protection supports rural development in such countries. We begin from the hypothesis that it is possible to generate technologies in local areas of knowledge and that, when managed by small national companies, such technologies can contribute to the sustainable

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development of economies and better conditions for rural producers.

The current economy has been characterized as the unity of time and labor, wherever that unity can occur [4]. However, note that not everything assumes the global scale that, for example, appears in the activities of corporations, whose production and employment generation eventually materialize at the regional level. Technology represents a fundamental element in the explanation of regional development. Thus, successful science and technology policies are aimed toward regions in which there are key actors to generate the process of technological change [5].

De Janvry and Sadoulet [6] argue that technological change can help increase the welfare of those who adopt innovations. This benefit occurs indirectly through the effect of these technologies on, for example, food prices, employment and wages in agriculture. The use of biotechnology has significantly increased in recent years. For example, since the 1980s, the number of intellectual properties (IPs) such as patents in the area of agricultural biotechnology has exponentially increased [7]. Biotechnology applications represent a wide range of opportunities, primarily in areas such as health (human and animal), the agri-food sector (i.e., agriculture, fisheries, forestry and food processing) and the environment (i.e., industrial processing, natural resources, environmental services and platform technologies) [8]. An example is the case of biofertilizers, whose use has been increasing because of the benefits that have been associated with them, i.e., enhancing productivity or addressing problems that arise in the development of multiple crops because of diseases and adverse weather.

Lyson [9] demonstrates how large corporations function as primary creators and disseminators of the most advanced biotechnological advances and that it is through IP mechanisms that these corporations profit from genetically modified products. Thus, the options for underdeveloped countries concerning IP in agricultural biotechnology are related to the use and acquisition of private and public technologies, to the development and protection of national institutional inventions and to the generation of technology transfer alternatives.

In the first and second cases, few underdeveloped countries have IP options for the protection of these inventions. The best alternatives are trade secrets, agreements to transfer these materials, access to technical knowledge, intellectual property rights abroad and the generation of technology transfer mechanisms in line with the technological interests of a given nation [10]. In addition, despite the technical potential of biotechnology to solve various problems, it remains unclear whether social institutions will be able to adopt and use this technology to satisfy the needs of society and improve social welfare [11]. Legal safeguards for endogenous inventions that occur in the agricultural area could be supported by intellectual property mechanisms. Such support becomes necessary with respect to the accumulation of technological capabilities, as represented by the case of biotechnological products and, specifically, biofertilizers in this discussion.

Since the development of new technologies and the increase in the global population, the form of agricultural production has changed. Although the family farm represents a special interest at the micro level, at the macroeconomic level, i.e., as a form of mixed production (crop and animal), the trend in developed countries is the specialization of large-scale crops that support animal production [12].

For example, McMillan, Narin and Deeds [13] explain how biotechnology has spawned a new industry of small companies with strong links to university scientists whereby the latter play a predominant role in the transfer of knowledge from universities to the market or in creating spinoff companies [14]. However, as previously mentioned, the main barriers to the development of a

biotechnology industry have been institutional constraints and a lack of skilled human capital in the universities, government research laboratories, and private companies in regional areas [15].

The knowledge and confidence of users concerning the use of agricultural biotechnology are basic elements with respect to the adequate management of the risk perception of these technological assets. Thus, objectivity and transparency in the assessment, management, and communication of knowledge in the area in addition to the inclusion of concerned parties become necessary [16]. Academia, government, business and peasants must work together to overcome technical, legal and operational barriers, not only to increase the availability of food but also to provide for its consumption under conditions of biosafety and availability of information for the population.

As Persley [17] argues, biotechnology is a tool that can contribute to solving food problems. Although the risks are not well understood, to help individuals make better decisions, it is necessary to ensure access to stakeholders through a framework of appropriate information. Thus, it is necessary to provide the best means of access to new technologies, generation of new requirements on public policy matters and necessary institutional arrangements for all stakeholders. These efforts involve social capital in the form of accumulated knowledge in an endeavor to reflect the different perspectives, such as community, institutional, networking and synergy perspectives, that facilitate the improvement of living conditions for the general population through the application of this discipline [18].

Therefore, in-depth studies that ensure the appropriate use of biotechnology applications and their products are required. There has been discussion concerning the social acceptance of biotechnology. It has been demonstrated that a policy concern exists in several countries (primarily in Europe), in which public opinion concerning agricultural biotechnology could impede the progress of such technology. Studies have observed how consumer support can be increased as long as benefits outweigh risks, as in the case of medical biotechnology in Europe, for which the level of acceptance is high in contrast to that of agricultural biotechnology, whose support is low [19].

Addressing the acceptance of biotechnological products by consumers, Aldrich and Blisard [20] performed a case study on the production of a biotechnological food product of animal origin. The authors conclude that consumers doubted the scientific evidence (i.e., perceived the issue as an aspect of food safety and welfare) and scientific results in matters of biotechnology. Thus, controversy was created. However, even when controversy occurs, consumption demand might overcome adverse effects or minimize them. The absence of reports of harm and government regulation could promote acceptance of the results of the use of biotechnology. Another problem is that the development, promotion and application of biotechnology is controlled by large corporations, despite the long history of genetic research in agriculture that has been conducted in underdeveloped countries such as Mexico, Brazil and India [21]. In addition, there are several biotech companies in Latin America, particularly in the health industry, that have achieved success in the market by following innovative strategies that helped them generate competitive advantages [22]. Therefore, similarly, in the area of agricultural inputs, biofertilizers might be an option for the creation of enterprises in underdeveloped countries that, with the cooperation of academia, government and business, create initiatives that favor farming and benefit scientific and technological development in these countries.

Previous empirical analyses of innovation studies have focused on large corporations. However, in recent years, a significant amount of innovative activity has been observed to occur in small businesses, particularly in new industries and emerging areas of

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