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SPECIALIST OPINION ON THE RELEASE OF TRANSGENIC CROPS IN MEXICO

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ABSTRACT

Mexican scientists specializing in food security, plant breeding and agrobiotechnology manifest different opinions, regarding the adoption of transgenic crops. We need to comprehend their criteria in order to strengthen impact studies and risk analysis, as well as to promote decision-making regarding the use of this technology, which is still being debated in Mexico. This study took place in 2015, intending to analyze the opinions of scientists who research agrobiotechnology, comparing the concerns of those specializing in biological issues to those specializing in social issues, in order to determine the main risks that they perceive for indigenous communities, regarding the introduction of transgenic crops. To do this, a questionnaire was applied to a select group of experts in transgenic crops, plant breeding and food sovereignty. We found that 70.6% oppose the release of transgenic crops during the commercial phase and that this figure increases to 94.1%, in the case of corn (maize); 96% think that it is possible that these will enter indigenous territory, to the advantage of the seed companies' business. We conclude that in Mexico, the release of transgenic crops does not take into account the viewpoint of national researchers, who for the most part, believe that this technology will have negative effects, mainly, on the diet and economy of peasants, so that from this perspective, they represent a threat to Mexico and in particular, to indigenous communities, as their community capital, self-determination regarding the use of seeds and genetic diversity are put at risk.

Key words: corn (maize), indigenous, peasant agriculture.

INTRODUCTION

Few scientific advances have caused as much controversy and polarization in terms of opinion, as Genetically Modified Organisms (GMOs). They have aroused all kinds of opinions and concerns among academics and consumers (International Service for the Acquisition of Agri-biotech Applications, 2014), since first being sown for commercial purposes in 1994. The surprising thing is that 28 years later, opinions remain divided, because transgenic crops comprehend various elements and those who promote or reject them, tend to prioritize one of these.

Within the scientific community, the debate mainly focuses on technical aspects related to environmental impact, consequences for animal and human health or gene dispersal by pollination (Foyer and Bonneuil, 2014; Hofmann *et al*., 2014; Vallaeys *et al*., 2017; Duncan *et al*., 2019) and socioeconomic aspects, which seek to determine the economic viability of this type of crops (Brookes and Barfoot, 2018). Topics such as food security and sovereignty, political aspects, social equity and the impact on ways of life and agri-food production in rural areas have been less studied, although there is growing interest in this area (Castellanos and Bergstresser, 2014; Mullaney, 2014; Wilson, 2015; Agapito-Tenfen and Wickson, 2018).

In Mexico, the Ley de Bioseguridad de Organismos Genéticamente Modificados (LBOGM) (Genetically Modified Organism Biosecurity Law), citing current legislation that regulates genetically modified organisms, establishes that decision-making for the approval of GMO planting permits must be based on technical and scientific aspects (New Law DOF 18-03-2005, 2005). This stipulates the formation of a Scientific Advisory Board, as a mandatory consultation body, made up of experts from various disciplines. However, the lines of research of those who currently research and publish on transgenic crops and related topics manifest disparate opinions and concerns, representing a challenge for decision-making and focusing efforts that will result in a proposal for national agro-food development.

To date, no study has analyzed the opinion of scientists working on issues related to transgenic crops, considered of great importance for determining Mexican research trends, and to enrich knowledge that will establish or strengthen impact studies and risk analysis. Addressing these aspects may be the basis for ultimately favoring the decision-making process regarding the use of this technology. Given this lack of information, this study aims to analyze the opinions of those who conduct research on agrobiotechnology and related topics, to compare the concerns of those specialized in technical issues and those of experts concerning social issues, and thus determine the main risks that they perceive for indigenous communities, in relation to the introduction of GMOs in their territories.

THEORETICAL FRAMEWORK

The cultivation of genetically modified seeds has been proposed as an alternative that could boost rural development in terms of yield, sustainability and food quality. In countries such as the United States, Canada and Argentina, improvements in agricultural production have been observed following the implementation of GMOs for commercial purposes, from 1994 onwards (Massieu-Trigo, 2009). In Mexico, the first request for GMO planting at the experimental stage occurred in 1988, for the FLAVR-SAVR tomato

variety. In 1996, the planting of genetically modified cotton began, followed by the commercial planting of transgenic soybeans. Thus, in 2009, our country occupied fifteenth place among countries that employ these technologies, with 0.1 million hectares planted (Martínez, 2011). Since 2009, experimental testing with transgenic corn has been permitted, although companies promoting this type of seed continued to pursue the release of transgenic corn in the commercial phase.

Conversely, in the face of the rapid advance of applications and planting of GM crops in Mexican territory, legal frameworks had to be implemented to regulate these applications. The Norma Oficial Mexicana (Mexican Official Standard) NOM-056-FITO-1995, cancelled in 2009, was the first legal instrument in our country to address the situation of GMOs (Colmenares and Ortiz, 2015). This established the phytosanitary requirements for the national mobilization, importation and establishment of tests on manipulated organisms, through the application of genetic engineering Diario Oficial de la Federación (Official Gazette of the Federation), 1995.

Later, in 2000, Mexico signed the Cartagena Protocol on Biosafety. This undertaking implied a commitment to enact a law on biosafety, which was implemented five years later. On March 18, 2005, the Law on Biosafety of Genetically Modified Organisms (LBOGM) was published in the Official Journal of the Federation, with the purpose of "regulating the activities of confined use, experimental release, release in a pilot program, commercial release, marketing, import and export of genetically modified organisms, in order to prevent, avoid or reduce any possible risks that these activities could pose to human health or the environment and to biological diversity or to animal, plant and aquaculture health (New Law DOF 03-18-2005, 2005).

The importance of mentioning the legal framework that accompanied the introduction of GM crops in Mexico lies in the fact that from its initiation, the fundamental role of the participation of scientists and experts in decision-making was recognized. The NOM-056-FITO-1995, mentioned in its second paragraph, the formation of the National Committee on Agricultural Biosafety, which would be made up of "a collegiate body of specialists in related matters" (Official Gazette of the Federation, 1995). Likewise in its article 20, the LBOGM, which is the current regulation, establishes the formation of the Consejo Consultivo Científico de la Comisión Intersecretarial de Bioseguridad de los Organismos Genéticamente Modificados (CIBIOGEM) (Scientific Advisory Council of the Intersecretarial Commission on Biosafety of Genetically Modified Organisms) with participation on the part of the Consejo Nacional de Ciencia y Tecnología (CONACyT) (National Council of Science and Technology) to form this committee. Likewise, Article 20 establishes that the technical opinions issued by the Scientific Advisory Board must be

considered by CIBIOGEM in the decisions it adopts (New Law DOF 18-03-2005, 2005). Beside this, in Article 9 of the LBOGM, in section VI, the relevance of the knowledge, opinions and experience of national scientists is mentioned in order to guide the regulation and administration of activities concerning GMOs (New Law DOF 18-03-2005, 2005).

Based on the above, it is necessary to understand these opinions and experiences in order to formulate a broad overview for decision-making and to define the direction of national scientific research on GMOs.

METHODOLOGY

The first aspect to be considered was, to which group of people, should the question be directed. Other studies have considered the general public (Desaint and Varbanova, 2013; Bevanda *et al*., 2017) or a certain sector of society, such as consumers (Wunderlich and Gatto, 2015; Palmieri *et al*., 2020), students (Ekborg, 2008) or only scientists (Aleksejeva, 2014; Naegeli *et al*., 2017; Mullins *et al*, 2022). However, for this study, we decided to conduct a survey of people with greater knowledge on issues related to genetically modified organisms (experts or scientists in the social and biological context), meaning it would only be directed towards individuals who did research on the subject, indicated by their scientific publications. This means that the opinions collected are mainly based on knowledge generated by researchers and obtained from more reliable sources of information.

The initial phase involved the selection of experts to whom the questionnaire would be applied. To do this, search engines such as Google Scholar, Dialnet, Scielo and ScienceDirect were used, to which the following keywords were entered: "Transgenics Mexico", "Food Security Mexico" and "Genetic Improvement Mexico". Data relating to the corresponding authors of each article was recorded, resulting in the construction of a directory of 102 experts, the vast majority of whom were Mexican. A request was sent explaining the reasons and objectives of the research, as well as an online questionnaire to all experts, to which they were urged to respond within a period of approximately one month. A positive response was obtained to this request in twenty-five cases, equivalent to a sample size of 24.5%.

Moreover, we sought to directly interview scientists who are openly involved in this issue, whether in favor or against. Four interviews were conducted; two of them with researchers holding an openly favorable opinion and two with specialists, who openly disagree with transgenic crops in Mexico. These four scientists work in technical areas; however, the two who are against are involved in social projects.

The scientists specialized in the technical or biological area and the specialists in the social area were grouped together to facilitate comparison and analysis.

In the technical area, there were 7 specialists in plant genetics, 3 in seed agronomy, 2 in nutrition, 2 in agronomy, 1 in plant physiology, 1 in crop production and 1 in plant biology, reaching a total of 17 respondents. 8 experts from the social context participated, of which 2 specialize in rural sociology, 4 in sectorial economics, 1 in human geography and 1 in cultural anthropology. 64% of participants belong to the National System of Researchers; with an age range of 37 to 79 years of age, averaging 53 years; the years elapsed since obtaining the last academic degree vary between 3 and 40 years, with an average of 16 years.

The scientists consulted belong to various national and international institutions. One belongs to the Center for Research and Advanced Studies in Social Anthropology, 6 to the College of Graduates, 1 to the College of the Southern Border, 4 to the National Institute of Forestry, Agricultural and Livestock Research, 1 is retired, 1 from McGill University, 1 from Save the Children, Mexico, 1 from the Autonomous University of the State of Morelos, 1 from the Autonomous University of Tlaxcala, 2 from the National Autonomous University of Mexico, 3 to the Autonomous University of Chapingo, 1 from the University of Sonora and 1 from Ohio State University.

All scientists reside in Mexico, with the exception of two researchers from the United States and Canada. The states where they reside include Campeche, Chiapas (2), CDMX (2), State of Mexico (9), Guanajuato, Jalisco (2), Michoacán, Morelos, Puebla, Sonora, Tamaulipas and Veracruz.

The survey, conducted via Google Forms between April and May 2015, consisted of 37 questions, mostly multiple choice: 15 of a personal nature to determine the participants' backgrounds; 6 focused on determining the opinion of scientists regarding the release of genetically modified crops at different stages and depending on the crop; 6 seeking to determine the risks, consequences and type of impact of these crops on the peasant context; 8 questions seeking to understand whether there is interest in introducing this type of crops into indigenous territory and one question about Mexican legislation on biosecurity; and one open question about the use of transgenic corn in Mexican agriculture.

The responses were automatically entered into a Microsoft Excel® spreadsheet. The frequencies of each response were analyzed and compared according to the participants' area of scientific specialty.

RESULTS

Of the four interviews conducted directly, two responded that they are totally against the use of transgenic technology in Mexico in any of its forms, due to the impossibility of controlling the externalities that they entail and the uncertainty that they generate, mainly concerning interaction with the

environment. The other two declared themselves in favor of the use of this technology, as they consider that it has numerous advantages that would benefit the Mexican countryside, as long as the crops comply with LBOGM provisions and the Regulations inherent in this Law are applied.

The general opinion of the scientists surveyed, grouped as "technical" and "social", was classified with respect to the phases of release of transgenic crops: experimental, pilot and commercial, as well as in a specific section to express their point of view regarding the release of transgenic corn during experimental and commercial phases. The group of social scientists disapproved of all release of transgenic crops beyond the experimental phase, whereas the group of scientists from technical areas were open to this, although the figure decreased drastically in the case of corn during the commercial phase (5.9% in favor and 94.1% against) (Table 1). Opinion "in disagreement" predominated in both groups and increased as the release phase progressed from experimental to commercial; that is, the Mexican scientists surveyed support the research and controlled study of this type of crops, however, they do not yet consider them ready to be openly propagated in the Mexican countryside.

The question was asked about the type of medium- and long-term impact (on a scale from very negative to very positive) that the planting of corn and other transgenic crops currently available on the market could have. The group of researchers in the social area did not contemplate any positive effect, as contrarily, they tend to consider that this will be very negative. The group of experts in technical contexts responded, to an even greater extent, that the

Table 1. Opinion of experts depending on their academic orientation, regarding the release of transgenic crops and the release of transgenic corn in Mexican territory

	Technical (%)		Social (%)		Con	TiF	TAg
	A	DA	A	DA			
- Regarding the release of transgenic crops at an experimental level	35.3	47.1	12.5	75.0	16.0	28	56
- Regarding the release of transgenic crops at pilot level	17.6	70.6	0.0	87.5	12.0	12	76
- Regarding the release of transgenic crops on a commercial level	17.6	70.6	0.0	87.5	12.0	12	76
- Regarding the release of transgenic corn at an experimental level	41.2	52.9	0.0	100.0	4.0	28	68
- Regarding the release of transgenic corn on a commercial level	5.9	94.1	0.0	100.0	0.0	4	96

A: Agree; DA: Disagree, Con: Conditional (Respondents who answered "it depends" without giving any other details); TiF: Totally in Favor; TAg: Totally Against.
Source: self-elaborated with data from the survey.

impact will be negative, although there are those who believe that there are positive aspects (Table 2).

Among the group of scientists specializing in technical aspects, it is notable that greatest concern was regarding pollen dispersal and the consequent loss of genetic diversity; the peasant economy and intellectual property aspects occupied second place. Social scientists stated that the most important impact of this type of crops is on food sovereignty; likewise, conflicts involving intellectual property occupied second place (Table 3).

Because one of the greatest concerns involves the dispersal of pollen, especially from transgenic corn to native varieties, scientists were questioned about level of risk (Table 4). Most experts in social issues considered that the risk of gene dispersal is very high, whereas among experts in technical areas, there is a greater diversity of opinions, ranging from those who consider that the risk is zero, to those who consider that the risk is high.

Those who support the planting of transgenic seeds state that "nothing happens if they are dispersed" or that "they do not imply greater risk than planting any other introduced variety" and that the use of this type of seeds, "if the essence of the agricultural style of indigenous communities is maintained, will add

Table 2. Scientists' perspective on the likely impact of planting corn or other genetically modified crops in the Mexican countryside.

Type of impact	Technical (%)				Social (%)			
	P	NI	N	VN	P	NI	N	VN
- Overall impact on the Mexican countryside	20.0	13.3	46.7	20.0	0	12.5	37.5	50.0
- Impact of planting transgenic corn in Mexico	6.3	12.5	41.7	31.3	0	12.5	25.0	62.5
- Impact on the peasant economy	6.7	20.0	46.7	26.7	0	0	25.0	75.0
- Impact on peasant diet	6.3	25.0	56.3	12.5	0	12.5	25.0	62.5

P: Positive; NI: No impact; N: Negative; VN: Very negative.
Source: self-elaborated with data from the survey.

Table 3. Potential consequences of the release of GM crops, as mentioned by experts.

	Technical (%)	Social (%)	Average (%)
Pollen dispersal	29.4	12.5	21.0
Loss of food sovereignty	17.6	37.5	27.6
Environmental impacts/ecological imbalance	5.9	12.5	9.2
Genetic erosion (loss of genetic diversity)	29.4	0.0	14.7
Impact on the peasant economy	23.5	0.0	11.8
Intellectual property disputes	23.5	25.0	24.3
Others (unspecified)	17.6	12.5	15.1

Source: self-elaborated with data from the survey.

Table 4. Risk of transgene dispersal according to experts

	Very high (%)	High (%)	Medium (%)	Low (%)	None (%)
Social	75.0	25.0	0	0	0
Technical	35.3	35.3	11.8	11.8	5.9
Total	48.0	32.0	8.0	8.0	4.0

Source: self-elaborated with data from the survey.

genetic wealth." Specifically regarding the benefits of this technology, 88% of participants stated that transgenic crops do not benefit farmers and all social scientists and 82.4% of technicians corroborate this opinion. The experts with an opinion "in favor" mentioned that GMO crops are a strategy to modernize the Mexican countryside to improve food production and that the main benefits are environmental in nature, as they represent an alternative to the widespread use of toxic agrochemicals, as they represent less risk to human and animal health. Those against stated that there is no benefit, as problems faced by farmers can be addressed by implementing other approaches.

Regarding whether they consider the release of transgenic crops in indigenous communities to be possible and whether there is any interest, 23.5% of scientists in the technical field and 50% in the social field, believed that there is no interest in planting transgenic crops in indigenous communities. Those who, on the contrary, considered that the introduction of transgenic crops in indigenous territory is feasible, believed that the main interest is to favor the business of transnational seed companies. To a lesser extent, among scientists in the technical field, some also considered the attempt as a way of increasing productivity in the field.

Specifically, 64.7% of those interviewed in the technical area responded that the interest in introducing GMOs in indigenous communities was to benefit business of transnational companies, contrasting with 50% of those in the social area. 11.8% of those in the technical area responded that the interest was to increase productivity in indigenous fields, 5.9% stated that it was to solve pest problems, another 5.9% responded that the aim was to improve food security in these areas, and another 5.9% responded that the aim was to have greater control over indigenous territories; whereas the other half of the scientists in the social context consider that there is no interest in introducing GMOs in indigenous communities, compared to 23.5% of those interviewed in the technical context. 87.5% of the social scientists and 76.5% of the technical scientists surveyed consider that GMO crops in general represent a threat to indigenous peoples, which represents 80% of the total number of respondents. 84% believe that there is no knowledge about transgenic technology in the communities and that it is primarily the task of government institutions to

provide information about these technologies, so that indigenous communities can actively participate in decision-making.

DISCUSSION

Opinions and criticisms against the release of transgenic seeds are often assumed to be "unscientific" and subjective, especially by those who promote the use of this technology (Qaim, 2016). It is apparent that in the case of Mexico, a part of the scientific community is in disagreement. These unfavorable opinions towards the planting of transgenic crops may be largely due to the lack of conclusive information on the impacts on a larger scale and to the fact that risk analyses do not cover the wide range of aspects that are involved in the release of GMOs. In other words, the rejection of this technology correlates with the level of existing knowledge about all aspects covered by this type of technology (Lucht, 2015; Meillet *et al*., 2015).

Scientists revealed greater concern about aspects related to their area of expertise, which implies that their opinions are based on their respective lines of research. However, it is worth mentioning that specialists in social issues are those who contemplate higher risks because they assign great importance to the cultural aspects of agriculture in the peasant and indigenous regions of the country; aspects that could disappear (Stone, 2011; Kranthi and Stone, 2020). The difference of opinions related to the area of expertise was also reported by Palmieri *et al.* (2020). As this topic is very controversial, social disputes around GMOs will probably continue to be a topic of public and academic interest in the near future (Motta, 2014).

Notably the scientific community; specialists in agrobiotechnology, food security and genetic improvement, is mostly opposed to the widespread use of transgenic technology in the Mexican countryside, especially when the corresponding law establishes that decision-making will be guided by "the knowledge, opinions and experience of scientists, particularly those pertaining to this country" (New Law DOF 18-03-2005, 2005). If we add to this fact that 100% of those surveyed and two of those interviewed perceive that Mexican legislation is deficient in matters of biosecurity, the disarticulation between those who generate knowledge and those who make decisions, becomes evident.

The recurring discourse regarding the territories destined for the sowing of transgenic crops states that it is practically impossible to introduce these crops into indigenous territories, as the LBOGM allows the establishment of GMO-free zones for the protection of agricultural products and biodiversity; likewise, it considers the right of communities to prior consultation, as well as studies on socioeconomic considerations. These ideas are also defended by scientists who openly support the use of transgenic crops in the Mexican countryside.

Here is a verbatim quote of one of the opinions: "This is impossible from the very start. There are areas in which, according to the definition of the Law on Biosecurity of Genetically Modified Organisms, release is not permitted; therefore, from my point of view there are no possible consequences from the introduction of transgenic crops in an indigenous community, because there is no possibility that this release would be permitted in these areas."

In contrast to the above opinions, those who oppose the use of this type of technology state that, "it is possible that transgenic crops will be released in indigenous areas, in order to break their autonomy, their sovereignty in the production and consumption of food, to make them dependent on large companies, to occupy and dominate their territories; or that an involuntary introduction may occur due to inadequate seed management by the farmers themselves."

Even though many believe that there is no interest in introducing transgenic crops in indigenous areas and that the law protects these areas, evidence provided by the application and resolution processes for permits for planting transgenic crops (National Service for Health, Safety and Agri-Food Quality-SENASICA, 2015), reveal that these statutes have not been respected. In May 2012, the permit for the release of Soya Solución Faena® was granted without considering that it would invade indigenous territory and compromise the economic activities of Maya, Huasteca, Nahuatl, Pame, Tepehua, Popoluca, Totonaca, Chol, Mame, Tzeltal, and Tzotzil communities in the states of Campeche, Quintana Roo, Yucatán, Tamaulipas, San Luis Potosí, Veracruz, and Chiapas, thereby violating the right to prior, free, and informed consultation (Comisión Nacional de los Derechos Humanos-CNDH and González-Pérez, 2015). This reveals that there is an intention to expand the area of GM crop cultivation to include more than territories in the north of the country where agriculture is mostly of industrial type; although there are also latent implications in these territories (Chauvet and Lazos, 2014).

In Mexico, State policy implemented by decision makers and institutions are continually questioned, resulting in general distrust and lack of governmental legitimacy (Morales, 2015). Therefore, in addition to a deficient regulatory framework, implementation of policy is unreliable, calling into question the motivation of government agencies. These uphold a neoliberal development paradigm that promotes industrialization, the privatization of natural resources and favors biotechnology companies (Fischer *et al*, 2015; Bogert *et al*., 2022), generally over the interests of small farmers, whose uses and customs are contrary to the dynamics proposed by these companies.

In this sense, it has been established that the rejection of new agricultural and food technologies correlates with political and economic ideology and that once an opinion is formed, it is difficult to change it (Lucht, 2015). This takes

the debate on transgenic crops to another level and complicates consensus among the scientific community, consumers, farmers and legislators.

Currently, biotechnology is evolving and finding ways to mitigate the risks involved in the release of genetically modified seeds (Fernández-Cornejo *et al*., 2014; Kumar *et al*., 2020); for example, by introducing modifications in chloroplasts to avoid gene flow via pollen (Daniell *et al*., 2005; Gressel, 2014), the insertion of stacked events to avoid the development of resistance in plants or insects, or by adding characteristics that solve the problems that most concern farmers (Chauvet and Lazos, 2014; Lazos, 2014). However, the radicalization of opinions can prevent progress in this scientific discipline, especially if those who give their opinion do not have sufficient, correct and up-to-date knowledge about genetically modified organisms and their implications for ecology, indigenous communities, peasant economy and food sovereignty in Mexico.

CONCLUSIONS

It is often mentioned that the rejection of transgenic crops comes from a fundamentalist position, especially from poorly informed consumers and environmentalists. The evidence from this study shows that this is not the case in Mexico, as the majority of experts in agrobiotechnology, genetic improvement and food issues, who participated in the study were of the opinion that there are many risks associated with the release of transgenic crops currently available on the market, especially in the case of corn.

The rejection of these varieties is related to lack of confidence in the legislation and policies of the companies that develop and sell transgenic seeds, not in biotechnology. This factor opens possibilities for the generation of technologies that do not compromise ecosystems, local varieties, traditional knowledge, indigenous autonomy or the local economy. Once these aspects are covered, the attitude towards transgenic crops or new technology might change and become more favorable.

The opinions and concerns of scientists specializing in social and technical areas, collected in this research, must be taken into account when preparing the impact studies and risk analysis "case by case" and "step by step" established by the LBOGM, so that they consider all possible scenarios, where the introduction of transgenic crops may have an impact.

Contrasting opinions are useful for broadening the perspective of all those involved and interested in these issues and to promote interdisciplinary and multidimensional scientific and technological development. In this way, it will be possible to defend, protect, appreciate and use one's own resources, as well as find a way to use the new technology available in favor of the interests of large and small producers.

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