









RESEARCH PAPER



Perception of genetically engineered crops in Paraguay

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ABSTRACT

Paraguay is integrated into the world mainly through its agricultural activity. The population's perception of genetically engineered crops is relevant to design communication strategies that convey the advantages and limitations of the various technologies used in the country. We aimed to know the perception of the population of four Departments of the country where such crops are grown through a survey, which revealed a low level of knowledge about genetically engineered crops in general, and specifically about the effects of genetically engineered crops on production, nutrition, and the environment. Respondents expressed a willingness to receive information on genetically engineered crops, in particular from the *National Government and the Health Sector*.

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Context

Over the past 25 years, many genetically engineered (GE) crops have been developed through biotechnology with the aim of boosting productivity, by reducing susceptibility to certain pests and agrochemicals, or enhancing nutritional value.¹ This, in turn, has generated a debate on the risks and opportunities involved in their deployment.

The World Health Organization, the Food and Agriculture Organization of the United Nations, and the Organization for Economic Cooperation and Development refer that the safety of any new food for human consumption must be carefully assessed, and guidelines have been developed in this regard [2–8]


In the field of food technology, techniques involving the use of microorganisms to process certain foods are applied. These techniques, which involve living organisms to modify or produce new products, are now known as “biotechnology”. New knowledge of molecular biology has led to the development of genetic engineering, a set of new techniques that make it possible to modify the


genome of living organisms with precision. The application of genetic engineering to food has made it possible to obtain GE foods.⁹

The production of GE crops has generated a diversity of opinions regarding their use in the international community.^{10,11} In this context, public perceptions of biotechnology and particularly the inclusion of GE crops in food vary in different developed countries and appear to be less receptive in European countries than in the United States.^{12,13}

Opinions and decisions about GE crops are divided: their consumption and acceptance have spread in the United States over the past decade, as it has in the rest of the Americas, Australia, Asia, and Africa. However, Europe still shows some resistance to cultivating GE crops.^{14,15}

Paraguay is integrated into the world mainly through its agricultural activity and is among the ten largest producers of GE crops worldwide.^{16–18} According to the International Service for the Acquisition of Agri-Biotech Applications

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Table 1. Estimation of cultivated land in hectares for the three crops with approved GE varieties in Paraguay according to latest data from the Statistical Synthesis of Agricultural Production, Directorate of Agricultural Censuses and Statistics (DCEA/MAG), harvest of 2019/2020.

Department	Soybean	Maize	Cotton
Alto Paraná	950,000	300,000	150
Caaguazú	430,000	160,000	400
Canindeyú	660,000	240,000	100
Misiones	50,000	5,000	300

(ISAAA), the areas of GE soy production are Itapúa, Alto Paraná, Canindeyú, and Caaguazú; and the areas of GE maize production are Alto Paraná, Itapúa, and Canindeyú (Table 1).¹⁹

For this reason, it is necessary to collect local data on the population's perception of GE crops in order to support planners of communication strategies on the advantages and limitations of the various biotechnological products used in the country. Through this work, we sought to understand the attitudes, behaviors and level of information handled by the respondents regarding GE crops. To our knowledge, this is the first survey on the perception of GE crops carried out in Paraguay.

The information received by consumers plays a critical role in the innovation and adoption circuit of GE crops, hence the importance of knowing the sources of such information on issues related to GE foods, and how these sources influence their perception. This research aimed to find out the opinions of the population in the Departments of Misiones, Alto Paraná, Caaguazú and Canindeyú about biotechnology, biosafety, and GE crops, and the bases or incentives behind them.

Materials and methods

In order to find out what the inhabitants of the four mentioned Departments know and perceive regarding biotechnology, biosafety, and GE crops, a descriptive, diagnostic study of public perception was carried out, using a structured survey as a research method. The study by a non-probability sampling of consecutive cases was carried out in the period 2014–2016, in places with a large influx of people, such as Regional Hospitals, Governorate offices, Municipalities, Schools, Public

and Private Universities, and Public and Private Institutions, considering the age group as the main variable, with a range between 20 and 70 years. Other variables studied were: gender, level of education, and questions that inquired whether the respondents have heard about GE crops, their effects on the agricultural, nutritional, and environmental sphere, whether they consume foods derived from GE crops, and where they received their information about GE crops from (Table S1).

The Departments of Misiones, Alto Paraná, Caaguazú, and Canindeyú were selected for being Departments where soybeans, corn, and cotton are grown. These crops have GE varieties approved in the country. Representative sample numbers were calculated for each Department according to the number of inhabitants; the General Department of Statistics provided all relevant data for this purpose, Survey and Census (alpha error = 0.05, 95% confidence and 50% knowledge in reference to the subject studied).²⁰

The survey technique consisted of collecting information on a population where contact is made directly with the study units (individuals, families, organizations, etc.), through a questionnaire; only a part of the population of each selected Department was observed, which was representative of the total, as the prediction error was measurable.²¹ The survey was structured with 35 variables, with the aim of studying the sample's overall opinion or appreciation of GE crops. A total of 1207 subjects were surveyed.

The design of the survey in its different facets, data collection, and statistical processing was in charge of technical professionals trained by the National Institute of Food and Nutrition (INAN), dependent on the Ministry of Public Health and Social Welfare; and the Faculty of Exact and Natural Sciences (FACEN), of the National University of Asuncion.

Data collection

A survey was conducted encompassing 1207 individuals from 4 different cities: Ciudad del Este, San Juan Bautista, Coronel Oviedo, and Saltos del Guairá. Surveyed individuals were number-coded from 1 to 1207.

The variables assessed regarding personal traits of the subjects and their perception of GE crops can be observed in Table S1, which contains the questionnaire applied.

For the section of assessment of knowledge about GE crops, 7 of the 35 variables of the questionnaire were considered, which were coded as detailed in Table 2, assigning the value 1 to the answers that indicated knowledge, and 0 to those that indicated lack of knowledge. Proceeding in this way, a maximum possible score of 7 was obtained, and by setting a criterion of knowledge of 70%, it was established that those surveyed should accumulate at least 5 points to be considered as people who knew about GE crops for the purposes of this study.

Statistical analysis

Multiple Correspondence Analysis (MCA) was used to analyze the data. MCA has the advantage of analyzing categorical data in multivariate space which can explore relationships among dependant and independent variables simultaneously.

For the MCA, the packages {FactoMineR}²² and {factoextra}²³ were implemented within R software [R.24] The dependent variables (the question of interest) were “Do GE crops present any danger?”,

“GE crops have effects on food”, “GE crops have effects on the environment”, and “GE crops have effects in agricultural production”.

The independent variables where: “Level of education,” “Gets Science information from TV,” “Gets Science information from the Internet,” “Heard about Biotechnology,” “Knows about GE crops,” “There are GE crops in Paraguay,” “Bt corn, RR soybean and BtRR cotton are GE crops,” “Consumes GE,” “There is a government entity which regulates GE crops in Paraguay,” “Source of Information on GE crops,” “Receives information on GE crops from Producers,” “Member of Producer Organization,” “Receives information on GE crops from Environmental Organization,” “Member of Environmental Organization,” “Would like to receive information on GE crops,” “How would you like to receive information,” and “From which institution would you like to receive information.”

Results and discussion

The search for and development of methodologies to evaluate the media’s role in disseminating scientific research and its influence on public opinion are today’s most critical challenges,²⁵ which motivated this research.

Table 2. Variables considered for the evaluation of knowledge about GE crops and their assigned coding.

No.	Variable	Answer	Coding
1	Have you ever heard of modern biotechnology?	Yes	1
		No	0
2	Are there any genetically engineered crops in Paraguay?	Yes	1
		No	0
		Does not know	0
3	Are Bt corn, RR soybeans, and BtRR cotton genetically engineered crops approved for cultivation in Paraguay?	Yes	1
		No	0
		Does not know	0
		Positive effect	1
4	Do genetically engineered crops have any positive or negative effect on agricultural production?	Negative effect	0
		No effects	0
		Does not know	0
		Positive effect	1
		Negative effect	0
5	Do genetically engineered crops have any positive or negative effect on food/nutrition?	No effects	0
		Does not know	0
		Positive effect	1
		Negative effect	0
		No effects	0
6	Do genetically engineered crops have any positive or negative effect on the environment?	Does not know	0
		Positive effect	1
		Negative effect	0
		No effects	0
		Does not know	0
7	Do you consume food derived from genetically engineered crops?	Yes	1
		No	0
		Does not know	0
		Does not know	0

Paraguay is made up of 17 Departments and one Capital District, Asunción. From the geographical point of view, the country is divided into two regions separated by the Paraguay River: the Western Region or Chaco, where the largest Departments of the country are located (Boquerón, Alto Paraguay, Presidente Hayes); and the Eastern Region, where the remaining 14 Departments and the country's capital are located.

Most of the respondents belonged to the X Department of Alto Paraná ($n = 346$), followed by the VIII Department of Misiones ($n = 295$), the V Department of Caaguazú ($n = 292$), and finally the XIV Department of Canindeyú ($n = 274$).

Regarding the question "do you watch TV programs on science and technology", 763 respondents answered yes, while 426 answered no, and 21 did not answer.

On the question "Is there a Government Agency in charge of regulating GE crops in Paraguay?" 355 subjects did not respond, or responded that they did not know, as the same time as, they responded yes to the question "According to your judgment, are GE crops dangerous?".

Out of the 336 respondents who said no when asked "Have you heard about or do you know about GE (also called "transgenic") crops?" Over two-thirds gave no answer when asked if they were dangerous. Among those who answered, most said that GE crops are not dangerous. Of the 826 who reported that they had heard or knew about

GE crops, however, over half responded that they thought GE crops were dangerous, and almost a third of this group gave no answer (Table 3).

These results coincide with a study made in the region of Murcia where 47.4% of the population studied do not know if GE crops have genes,²⁵ which tells us that half the population has fundamental deficiencies in biological and genetic issues; this makes it difficult to form clear criteria when accepting or rejecting GE crops. According to a study carried out by the BBVA Foundation in nine European countries, GE crops are perceived as more harmful than beneficial, with a high rate of non-response.²⁶ On the other hand, in a survey about public attitudes toward GE applications done in the Netherlands, it was found that there was a significant and negative correlation between information-seeking behavior and acceptance of GE applications, as well as trust in governance, and trust in regulations.²⁷

Subjects were also asked whether GE crops had any positive or negative effects on agricultural production, food/nutrition, and the environment. The results are summarized in Table 4.

Over half of the subjects (619, 51.28%) did not respond or said that they did not know when asked the question "Do you consume foods derived from GE crops?" A similar trend was seen in a study conducted in the region of Murcia, Spain, in which when asked if they had ever consumed GE products, 51.1% of the participants said they did

Table 3. Comparison of results of two points from the questionnaire applied: "Have you heard about or do you know about GE (also called "transgenic") crops?" vs. "According to your judgment, are GE crops dangerous?."

Have you heard about or do you know about GE (also called "transgenic" crops?)	According to your judgment, are GE crops dangerous?						Total Count	
	Yes	No	No answer					
Yes	425	35.21%	148	12.26%	253	20.96%	826	68.43%
No	75	6.21%	28	2.32%	233	19.30%	336	27.84%
No answer	19	1.57%	6	0.50%	20	1.66%	45	3.73%
Total count	519	43.00%	182	15.08%	506	41.92%	1207	100%

Table 4. Assessment of GE crops' perceived effects on agricultural production, food/nutrition, and the environment.

	Do GE crops have any positive or negative effect on					
	agricultural production		food/nutrition		the environment	
Positive effect	321	26.59%	112	9.28%	77	6.38%
Negative effect	243	20.13%	324	26.84%	368	30.49%
No effects	60	4.97%	69	5.72%	75	6.21%
Does not know/No response	583	48.30%	702	58.16%	687	56.92%

Table 5. Institutions from which participants expressed the desire to receive information about GE crops.

Institution	Number of participants	
Specialized Institutions	2	0.17%
Private Companies	14	1.16%
NGOs	18	1.49%
Would not like to receive information	29	2.40%
International Organizations (FAO, WHO)	57	4.72%
No response	56	4.64%
University	92	7.62%
Scientists	105	8.70%
Healthcare Professionals	195	16.16%
National Government	236	19.55%
More than one institution	403	33.39%

not know, 30.5% said they had consumed them, and only 19.4% said they had never consumed them.²⁵

It was considered relevant that a large part of the sample expressed a preference for receiving information on GE crops from the National Government and the Health Sector (Table 5), data that we can relate to studies in which the professionals who inspire the most trust among the public are doctors and scientists; politicians, people in business and the media being those who inspire the least trust.²⁸

The 1996 and 1999 Eurobarometer results suggested no correlation between the availability of information and knowledge about biotechnologies and support for them. One factor to consider in terms of the perception of risks and benefits of GE organisms is the role of objective knowledge about them compared to how much knowledge subjects believe they have about the subject.^{29–33} Those who show the most extreme opposition to GE foods are also the least knowledgeable, but their perception of their own knowledge of the subject is also wrong, i.e. they think they know more than they actually do.³⁴

According to the data collected in this survey, of the 60 individuals who met the criteria for knowledge of agricultural biotechnology defined in this study's methodology, over a third consider GE crops to be dangerous (Table 6).

One observation that we consider relevant to make regarding the questionnaire is that we are aware of the two problems proposed by Hermann and collaborators³⁵ in assessing consumer concerns, one of which is the failure to establish the relevance of the questions to the respondents. Hence, when a topic is unfamiliar to them, their answers may be based on their general opinion of a subject rather than on actual knowledge. The other problem pointed out by the authors lies in the fact that the construction of the questions influences the answers obtained. These observations were taken into account both in the drafting of the questions and options and in the interpretation of the answers.

In a scenario composed of several sectors with opinions on the risks and benefits of GE crops where some of these sectors base their positions on misconceptions about both GE crops and their knowledge about them, government agencies could plan specific campaigns based on the demographic characteristics of each sector in order to overcome the barrier.

A Multiple Correspondence Analysis (MCA) analysis was performed with the data collected. Most of the variance was explained in the MCA's first two axes, with axis-1 having 23.8% and axis-2 with 18.9% of the variance explained (total of 52.7%) (Figure S1).

The dependant variables: "Do GE crops present any danger?," "GE crops have effects on food," "GE crops have effects on the environment," and "GE crops have effects in agricultural production" had different positions in the ordination space (Figure S2). Of these variables, the information corresponding to GE crops positively affected food, agriculture, and the environment did not contribute to the variance explained in axes 1 and 2 (Figure S3). There is a high correlation among variables that indicate No danger/No effect of GE crops and their

Table 6. Comparison of the perception of the danger posed by GE crops between subjects of the sample that met knowledge criteria about GE crops described in Table 2 and those that did not.

	According to your judgment, are GE crops dangerous?						Total count	
	Yes		No		Does not know			
Met knowledge criteria	21	1.74%	33	2.73%	6	0.50%	60	4.97%
Did not meet knowledge criteria	498	41.26%	149	12.34%	500	41.43%	1147	95.03%
Total count	519	43.00%	182	15.08%	506	41.92%	1207	100%

cognates (Figure S3). This is also seen with the variable of “Yes, GE crops are dangerous” cognates, and the variable of “I do not know” and its cognates (Figure S3). This indicates that only one variable can be selected in the future, predicting other viewpoints (i.e. if an individual answers that GE crops are dangerous, it would reflect that in his answers on effects in agriculture, environment and food).

In terms of determining if any of the independent variables and their levels (represented as 95% confidence interval ellipses) could differentiate the answers regarding the dependent variables, there was a great degree of overlap (not shown). Due to the degree of overlap and the nature of the data, it cannot be distinguished how these variables can predict individual response regarding GE crops.

The level of education of the respondents seems to have no significant effect on their answers. All variables presented a high degree of overlap.

Laypeople generally are unable or uninterested in investing large amounts of time and effort in acquiring in-depth knowledge about complex technologies, so when confronted with the need to evaluate information about GE organisms and their risks, they will rely mostly on their intuition.³⁶ Three components can lead to intuitive rejection of GE crops: one of them is called psychological essentialism, which is the belief that organisms possess an unobservable and unchanging core that determines their identity, development and behavior. The second is the feeling that the world was designed for a specific purpose, and that there is an order that must not be tampered with; within this context, genetic engineering is considered the opposite of “natural”, and those who oppose it accuse scientists of “playing God”. The third component has to do with emotions, and in particular with disgust; people react to GE crops more strongly than to GE organisms developed for other applications. Revulsion probably evolved as an adaptive response related to avoidance of pathogens and toxins.^{37,38}

The approach to communication aimed at subjects who express opinions against the implementation of GE crops would be greatly enriched by taking into account the fears and mistrusts that lead to a negative perception of GE crops,

particularly in terms of the companies’ motivations develop these products. In Europe³⁴ and Canada,³⁹ these fears were based on the possibility that corporations would monopolize the provision of food through propagating the use of patented seeds, but rather with the intellectual property model that governs GE crops. As for the concentration of the GE seed market, an OECD report states that although it is difficult to assess because of the limited availability of data and the existence of stacked events belonging to different companies; it is nevertheless observed to be much higher for GE seeds than for other seeds studied and that it is dominated almost exclusively by large multinationals.⁴⁰ However, it is pertinent to ask what factors cause market concentration (such as company mergers) and whether such concentration is always bad for consumers, both in terms of its impact on innovation⁴¹ and the level of prices⁴²; or whether it is relevant to completely rethink the system of intellectual property rights governing the development of GE crops, as the possibility of patenting sequences possibly diverts companies’ attention from the discovery of applications of the sequences to the stacking of intellectual property rights on the sequences themselves.^{43,44}

Regarding the environmental concerns surrounding the use of GE crops, the following have been identified in other studies: possibility that GE crops with insecticidal traits affect non-target insects,⁴⁵ or accelerate the emergence of superpests, possibility that GE crops with herbicide resistance might transmit the trait to weeds,⁴⁶ the danger that herbicide resistance might encourage overuse, and the danger to biodiversity posed by GE crops being planted in monocultures.⁴⁷

When analyzing the possible sources of conflict between the population and the new forms of food production, mistrust rather than ignorance could be addressed, and from that perspective, various possibilities could be explored. Some of these are listed below:

- (1) There is growing documentation in the critical scientific literature of cases in which corporations have engaged in negligent practices in the production, preparation, distribution and sale of food products in order to increase

their profit margins, and how these cases tend to be characterized as accidents or exceptions rather than corporate misconduct.⁴⁸

- (2) Scientists in life sciences feel less and less committed to studying major societal problems if there is a financial incentive to focus on a different research agenda.⁴⁹
- (3) Another factor to take into account is the confidence in the government as a regulator. A strong association has been found between exposure to corruption in the public sector and a lower likelihood of trust in the private sector.⁵⁰

The University as an institution is called to contribute to the dissemination of a technology that has provoked discussions all over the world, fulfilling its role of guiding society. In this survey, the University occupies the fourth place of reference through which the population would like to receive information on the subject. Within the group of government agencies, greater confidence was observed in the universities among the participants of the survey, which is in accordance with the observation by another study carried out in Costa Rica, that claims that university professors and scientists have greater credibility among the population in relation to other groups.^{51, 52}

A limitation this work presents is that perception of agricultural pesticide use was not assessed along with the perception of GE crops. Agricultural pesticides are usually negatively perceived by the public.⁵³ Considering that a wide variety of crops have been modified to confer herbicide tolerance and insect resistance, thus the traits introduced are directly related to the amount and type of pesticide to be used on them, communication campaigns on GE crops must include proper communication of the risk of the pesticides that accompany these crops, since even if the public is assured that the crops themselves do not present a danger, fear of pesticides or negligent pesticide management practices can still represent a significant barrier to their acceptance.

Conclusions

There is a low level of knowledge about GE crops in the sample surveyed. Even individuals who claimed to know about GE crops failed to adequately answer a sufficient number of questions

in the questionnaire's knowledge assessment section to be considered informed about the issue. The majority of participants reported having heard about GE crops. Of those who reported to have heard of GE crops, 15% said they were not dangerous; 43% said they were dangerous, and 42% said they did not know. A high percentage of respondents expressed a lack of knowledge about GE crops' effects on production, nutrition, and the environment. Considering the willingness of respondents to receive information on GE crops, it is vital that the appropriate government bodies design communication campaigns for these audiences to build trust between regulators and the public and enable consumers to make decisions based on reliable information.

Disclosure statement

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All authors participated in the drafting of this manuscript as individual experts in their fields, and are solely responsible for the contents.

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