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ARTICLE

Perception of producers and consumers on the adoption of genetically modified food: the case of the transgenic bean BRSFC401 RMD

Percepção de produtores e consumidores quanto à adoção de alimentos geneticamente modificados: o caso do feijão transgênico BRSFC401 RMD

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Abstract: Transgenic beans has encountered resistance to its dissemination in the market. This study investigates whether the new cultivar of transgenic beans (BRS FC401 RMD) developed by Embrapa, in Brazil, has the potential for adoption in the producer and consumer markets. We also aim to identify factors that explain this adoption. Through semi-structured interviews, data were collected from non-probabilistic convenience samples of 37 producers and 100 bean consumers in the state of Goiás, Brazil. Data were analyzed using descriptive statistics and logistics regression models. The results indicate that producers are prone to planting the transgenic bean, and the variables that explain this preference are: total area of property (in hectares), time of experience on the activity (in years) and bean bag sale price. It was also identified that consumers are willing to include transgenic beans in their diets, and the variables explaining this decision are: amount of information received, meaning of the symbol (T), product safety and reasons for consumption. This study contributes to discussions on the adoption of transgenic cultivars, especially those related to the new BRS FC401 RMD bean, highlighting aspects that can serve as input to the next stages of development of the cultivar.

Keywords: transgenic beans, BRSFC401RMD, perception of producers and consumers, logistic regression.

Resumo: O feijão transgênico tem encontrado resistência à sua disseminação no mercado. Este estudo investiga se a nova cultivar de feijão transgênico (BRS FC401 RMD) desenvolvida pela Embrapa, no Brasil, tem potencial para adoção nos mercados produtor e consumidor. Pretendemos também identificar os fatores que explicam essa adoção. Por meio de entrevistas semiestruturadas, foram coletados dados junto a uma amostra não probabilística por conveniência de 37 produtores e 100 consumidores de feijão no estado de Goiás, Brasil. Os dados foram analisados por meio de estatística descritiva e modelos de regressão logística. Os resultados indicam que os produtores estão propensos ao plantio do feijão transgênico, e as variáveis que explicam essa preferência são: área total da propriedade (em hectares), tempo de experiência na atividade (em anos) e preço de venda da saca de feijão. Também foi identificado que os consumidores estão dispostos a incluir o feijão transgênico em suas dietas, e as variáveis que explicam essa decisão são: quantidade de informações recebidas, significado do símbolo (T), segurança do produto e motivos de consumo. Este estudo contribui para as discussões sobre a adoção de cultivares transgênicas, principalmente aquelas relacionadas ao novo feijão BRS FC401 RMD, destacando aspectos que podem servir de subsídio para os próximos estágios de desenvolvimento da cultivar.

Palavras-chave: feijão transgênico, BRSFC401RMD, percepção de produtores e consumidores, regressão logística.

1 INTRODUCTION

Brazil is the third largest producer of beans in the world (Food and Agriculture Organization of the United Nations, 2017). The national production of beans, in 2017, was 1.2 million tons (Brasil, 2018), and was distributed among the states as follows: Minas Gerais (29.6%), Goiás (17.8%), São Paulo (15.1%), Paraná (13%) and Mato Grosso (9.1%). From 2003 to 2017, Mato Grosso and Goiás were the fastest growing producers (Empresa Brasileira de Pesquisa Agropecuária, 2019). In Goiás, Cristalina city is the largest producer, with 28.9% of the total amount produced in the state, with an average planted area, in the 3rd harvest, of 15 thousand hectares (ha), and average productivity of 2760 kg/ha-1 or 46 bags, between 2003 and 2017 (Instituto Brasileiro de Geografia e Estatística, 2017).

This production refers mostly to common beans (*Phaseolus vulgaris, L.),* one of the main crops produced in the world. For being rich in proteins, with an average consumption, in Brazil, of 17 kg/per capita/per year (Barbosa & Gonzaga, 2012; Brasil, 2018), beans are a fundamental staple food as well as nutritional security for the population, making the importance of these beans extrapolate beyond their economic aspect. However, the production of common beans faces major challenges. The first refers to the sensitive nature of the legume to diseases, pests and viruses. The second concerns the submission of production to a volatile market, whose production and productivity gains immediately depress prices. The third challenge relates to an inelastic demand due to the short grain longevity, which makes it difficult to implement production expansion strategies, aimed at food security for both domestic and foreign market populations.

The best alternative to overcome these challenges is by cultivating transgenic beans, which show relative resistance to viruses, have potential for productivity gains, and enjoy reduced average costs due to the need of less insecticide use. However, the use of transgenic seeds faces resistance from producers concerned with the possible increase in production and a consequent fall in prices in local markets. In addition, consumers worry about the intrinsic aspect of transgenic themselves.

The literature shows that the process of adopting genetically modified cultivars is complex and affected by a large number of factors, such as knowledge, perception of risk and benefit, and socio-demographic profile (De Steur et al., 2019). These factors interfere in the choices that producers and consumers make (Kimenju et al., 2005; Lassen & Sandøe, 2009). It is necessary also to consider that in these discussions of adopting transgenic are aspects involved such as food safety and ethics issues (Dibden et al., 2013; De Steur et al., 2019). Although the Embrapa has positively evaluated the agronomic performance of the BRS FC401 RMD transgenic bean cultivar in different Brazilian states at planting times, the launch of such technology has sparked discussions among those who have generated the company's technology themselves, due to the possibility of resistance from producers and consumers. This shows that even after considerable investment of material, human and financial resources in the implementation of the cultivar by Embrapa, doubts remain about its commercial viability.

This paper seeks to contribute to these discussions, by providing empirical evidence regarding the possible adoption/consumption of transgenic beans by producers/consumers. In this study, there was an interest in listening to producers and consumers of beans from the cities of Cristalina and Goiânia, respectively, after defining the research question: has this new cultivar of transgenic beans (BRS FC401 RMD) potential for adoption by the Cristalina producer's market, and consumption by the Goiânia's consumer's market? The objective is to identify which are the variables that explain both, the propensity of producers to plant the transgenic beans and the decision of consumers to consume them.

2. THEORETICAL FRAMEWORK

2.1 The transgenic cultivar BRSFC401 RMD

Genetic modification refers to the use of newer technologies by plant breeders (scientists/seed breeders) to intentionally make changes in the DNA of organisms, in order to obtain desirable traits (Food and Drug Administration, 2014). In common beans, several species of arthropods, pests and viral diseases are key factors that affect productivity. Among these species stands out the whitefly (*Bemisia tabaci*) - vector of the Bean Golden Mosaic Virus (BGMV) - which can cause significant reduction in crop yield (Quintela, 2001).

In order to select BGMV resistance genes, Embrapa scientists developed a mechanism known as pathogen-derived resistance, based on RNA interference strategy (Bonfim et al., 2007; Aragão & Faria, 2009; Faria et al., 2014). After extensive research into genetic engineering with common bean lines, Embrapa researchers identified the BGMV resistance gene (Faria et al., 2013). In September 2011, the genetically modified common bean cultivar (BRS FC401 RMD) was launched commercially worldwide by the National Technical Biosafety Commission (CTNBio) (Aragão & Faria, 2009). It was the first plant fully developed by a public research institute in Brazil, considering all plant cultures (Aragão & Faria, 2009).

The transgenic BRS FC401 RMD cultivar is the first Carioca Common Beans registered and protected Brazilian cultivar, with effective resistance to Golden Mosaic beans vírus, being the first genetically modified cultivar of common beans in the world. This resistance is conferred by the same transgene present in the Embrapa 5.1 event, represented by the by RMD sufix (Golden Mosaic Resistant) (Aragão & Faria, 2009; Souza et al., 2016). In the 31 VCU (Value of Cultivation and Use) carried out in Brazil in the rainy (in the states of Goiás, Paraná, and in the Federal District), in the dry season (in the states of Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Paraná, Santa Catarina, and in the Federal District) and in the winter season (in the states of Goiás, and in the Federal District), the BRS FC401 RMD presented superiority in grain yields if compared to conventional cultivars, besides effective resistance to Golden and common mosaic, moderate resistance to anthracnose and stain resistance (Souza et al., 2016).

The BRS FC401RMD cultivar was initially registered for rainy and winter seasons in Central Brazil region and stands out in sanity, presenting effective resistance to Golden Mosaic, besides rust and stain resistance. With relation to protein percentage, the BRSFC401 RMD cultivar average content is similar to the conventional bean Perola and BRS Pontal (Souza et al., 2018). The cultivar presents a normal cycle varying from 85-95 days, semi-prostrate architecture - recommended for mechanized harvest. Also, it presents a mass of 100 grains of 25g and expected yields of 4000kg per hectare (Souza et al., 2018).

BRS FC401 RMD represents a high-impact technological innovation for bean farmers in the country, since it is an important tool for the integrated management of viral diseases transmitted by the whitefly. The cultivar was initially registered for the wet- and winter-harvest seasons in Central Brazil. It presents a normal cycle, carioca-type grains with commercial attributes, good productive potential, grow excessively upwards then collapse, and have indeterminate growth habit (type III) (Souza et al., 2018).

Embrapa researchers faced norms, regulations and other blockages to be able to make available to farmers an important technological product for Brazil. One of the biggest problems faced by researchers involved in the production of this variety was the obligation (as mentioned in the old legislation) that field experiments (albeit in very small areas) be preceded by environmental impact studies and respective environmental impact reports. After much controversy, the transgenic bean has been approved by the National Technical Biosafety Commission (CTNBio), according to Opinion n. 3.024 of 16/09/2011 (Souza et al., 2016), but still awaits release for commercial use. The cultivar faces resistance at various levels of management at MAPA, reflecting negatively on Embrapa's performance (Buainain et al., 2014).

Technology adoption is the process of implementing the transference of knowledge about the technology (Rogers, 2003). In agriculture, this process will depend on farmers' perception of the benefits when adopting innovation and the gains in marketing (Forbes et al., 2013) from a micro viewpoint, the adoption of technology assumes that each decision element must choose whether to adopt innovation and its intensity of use. At the macro level, technology adoption studies look for adoption patterns across the population, or households, examining them over time to identify specific trends in the diffusion cycle (Feder & Umali, 1993).

Regarding the adoption of genetically modified cultivars, studies show that farmers' decisions are made based on several factors, such as: expected profit, availability of land, and ease of agricultural credit (Feder et al., 1985; Souza Filho et al., 2011), greater propensity to price and production risk (Abdulai & Huffman, 2005; Ashraf et al., 2009; Langyintuo & Mungoma, 2008), perception of lower production costs, reduction of pesticides and increased productivity (Almeida et al., 2015), scale of production (Abdulai et al., 2008), greater education and professional qualification (Feder et al., 1985; Lacky, 1998; Hartog et al., 2009), ability to obtain and process information, and ability to use agricultural techniques and management methods (Baron & Shane, 2008), professional experience in non-agricultural activities and exchange of information on social networks (Doye et al., 2000; Hartog et al., 2009). Studies also include the age factor, since youngers farmers have more knowledge about transgenic cultivars (Todua et al., 2017) and are more easily attracted to novelties (Anosike & Coughenour, 1990; D'Souza et al., 1993).

However, new transgenic technologies may not be adopted due to reasons such as: technology attributes (like relative advantage, complexity, compatibility, or divisibility), consumer opposition (as in the case of agricultural biotechnology), farm size, relative costs, and socioeconomic and localization characteristics of decision makers (Almeida & Massarani, 2018; Ugochukwu & Phillips, 2018).

2.2 Consumption Perception

Genetically modified foods are a hotly debated topic. Consumers are concerned about the higher risks associated with consuming these foods compared to traditional foods (Ballmer, 2018). Any attitude or action intended to influence this view point should not only be based on the benefits of the new product, but above all recognize that such concerns exist and are often legitimate.

The safety of genetically modified crops is crucial for their adoption by consumers and has been the subject of intense research work, often ignored in public debate. In reviewing the literature on important issues arising from the debate on safety of transgenic crops, the scientific consensus has matured, because since they became widely cultivated worldwide, no significant risk directly related to the use of transgenic crops has been detected; however, the debate is still intense (Nicolia et al., 2014).

While most of the processed foods contain transgenic ingredients, there are also transgenic fruits and vegetables available for purchase, including papaya, potato, apple and pumpkin varieties (Food and Drug Administration, 2015). Most transgenic foods have been developed to help farmers not lose yield due to drought, disease and pests, as in the case of the new BRS FC401 RMD bean cultivar. Such foods may benefit consumers, either by the lower use of chemical insecticides, resulting in lower costs, or by productivity gains, bringing about more affordable prices to consumers, in the market.

Messages have the potential to clarify, guide and influence the attitudes of individuals. Communicators and educators are aware of this fact, and also know of the importance of having a keen critical sense. Recognizing that consumers do not always have access to or clarity about available scientific information on transgenic foods, communicators and educators seek to facilitate that such information not only reaches consumers, but is presented in an assimilable manner. Consumer attitudes toward transgenic foods are often controversial, and sometimes some admit not to understand or have an opinion on the subject. Nevertheless, certainly they can be educated, leading to a reevaluation of their positions, facilitating their acceptance of new technologies and products. Additionally, with input from communicators and educators, there is always a tendency for communication among all to be more effective. Innovative products can result in nutritionally richer foods, leading consumers not only to have a better quality of life, but also have the opportunity to better utilize their financial resources (Funk & Kennedy, 2016).

Some studies have sought to identify the main characteristics that influence the acceptance of transgenic foods by consumers. The reports point to some factors, such as: perceptions about the potential benefits and risks of GM foods (Kikulwe et al., 2011), technology used in cultivation (Grunert et al., 2001), knowledge consumer opinion on transgenic food (Noomene & Gil Roig, 2007), , and socioeconomic characteristics such as age, education level (Canavari & Nayga Junior, 2009), family size and income (Rodríguez-Entrena et al., 2013) of the consumer. However, knowledge about the acceptance of GM foods by consumers remains limited (Rodríguez-Entrena et al., 2013).

3. MATERIAL AND METHODS

3.1 Survey Description, Sample and Data Collection Procedures

This research has an exploratory character and a qualitative and quantitative approach. This is a case study that seeks to identify the perception of potential rural producers and consumers of beans in relation to the new transgenic beans (Cultivar BRSFC401 RMD) being developed by Embrapa. Data on producers were collected in the city of Cristalina, the municipality responsible for the largest bean production in the state of Goiás, Brasil (Instituto Brasileiro de Geografia e Estatística, 2017). Cristalina was also the place where experiments were carried out with the BRSFC401 RMD cultivar, which is being developed by the Embrapa Rice and Beans Nucleus.

Considering that Cristalina has 80 agricultural establishments producing beans (Instituto Brasileiro de Geografia e Estatística, 2017), the sample of 37 responding producers, non-probailistic for convenience, has a confidence level of 90% and an error of 10%. Data were collected in January 2018, by the main author of this study, through semi-structured interviews, with closed and open questions, with 29 producers and 8 consultants. In the latter case, the consultants accounted for properties whose plantations they direct. Due to the lack of direct access to the properties, the sampling process took place using the snowball technique (Alonso et al., 2016), and is therefore not probabilistic by judgment.

Based on previous studies (Feder et al., 1985; Lacky, 1998; Abdulai et al., 2008; Ashraf et al., 2009; Hartog et al., 2009; Souza Filho et al., 2011; Almeida et al., 2015; Todua et al., 2017), information was gathered from producers on: age, gender, distance from farm to city, total area of property (in ha), level of education, place of residence, length of experience in the activity (in years), employed labor, property management and accounting, participation in cooperatives, access to assistance, cost control, working in bean technical groups, use of crop finance, bean planting season, planting crops, bean varieties used, area intended for bean planting, selling price of bean bag, sack yield per ha, planting techniques (no-tillage in straw), and soil analysis), types of crops on the property, percentage of income represented by beans, cultivation of other transgenic, insecticide use and whether to plant transgenic beans.

Consumer data were collected through semi-structured interviews with a non-probabilistic convenience sample of 100 bean consumers. The collection was carried out by members of the Association of Housewives in Supermarkets in the city of Goiânia, state of Goiás, Brasil, in January 2018. The interviews used a simple form with initial socioeconomic questions, complemented with questions related to the consumption of transgenic beans. Information was collected on the following aspects: age, sex, occupation, income, education, number of children, information on transgenic, means by which the information was conveyed, knowledge of the meaning of the transgenic symbol (T), and the search for design when buying products, safety of transgenic products and, lastly, whether or not the transgenic beans would be consumed, and what are the reasons for such a decision.

3.2 Data Analysis Procedure

Quantitative data analysis was performed in two steps. First, using descriptive statistics, frequency, calculations were made of the mean and standard deviation of the variables contained in the data collection instruments. Subsequently, through inferential statistics, relationships between the variables were sought.

Regarding the producers, it was sought to identify if they were prone to planting transgenic beans and what variables explained this propensity. The explained variable was "transgenic beans would be planted," measured in a binary format (1 - Yes; 0 - No). The explanatory variables were all the others, related to the producers, mentioned in the previous section. As for consumers, it was sought to identify whether consumers would consume transgenic beans and what variables would explain this decision. The variable explained were "would eat transgenic beans," also measured in a binary format (1 - Yes; 0 - No). The explanatory variables were the others, mentioned in the previous subsection, related to consumers.

In order to identify the relationships between the explanatory categorical variables (nominal and ordinal) and the explained variables (binary categorical), the Logistic Regression model was used, supported by the Likelihood Ratio test, selecting, as a starting point, the explanatory variables, automatically, through the Stepwise bidirectional technique. The Stepwise process creates variable combinations to select the model with the best information criterion (Agresti, 2019). The Bayesian information criterion (BIC) for small samples was applied to obtain the model best suited to the data conditions (Agresti, 2019).

4 RESULTS AND DISCUSSION

4.1 Producers

4.1.1 Characterization of the Producersv

According to data from the Agricultural Census 2017 (Instituto Brasileiro de Geografia e Estatística, 2017), the average area of the establishments of the Eastern Goiás region is 1,023.84

hectares (ha). In the case of the establishments sampled, whose areas range from 60 to 4000 ha, the average is 1,299.03 ha and the standard deviation is 966.77 ha (Table 1).

Table 1. Total Area of Bean Farmers Sample Properties in Cristalina, state of Goiás, 2018.

Property Total Area (ha)	Number of Producers	%
Until 400	7	18.92
Between 401 and 1200	12	32.43
Between 1201 and 2000	11	29.73
Above 2001	7	18.92
Total	**37**	**100.00**

Source: Research Data (2019).

Producers interviewed are diverse, since they cultivate other crops besides beans. Table 2 shows that 56.75% of the interviewed producers allocate 20 to 200 ha for planting beans. In 67.56% of them, the revenue from this crop represents 20 to 40% of the total property revenue, and in another 27.02%, it is between 10 to 19% of the total property income.

Currently, the average area allocated to the planting of beans is 232.36 ha, and the standard deviation of 197.07. However, in the past it was larger, since most producers (51.3%) state having reduced bean farming due to problems with the activity, among them, those related to the Golden Mosaic, corroborating the findings of Guivant et al. (2009). They then preferred to resize planting with other crops such as soybeans, corn, sorghum, wheat, tomatoes, garlic and onions. Nevertheless, the percentage participation of bean planting in the interviewed farms is still significant, especially the beans irrigated in the third harvest in winter, which is cultivated with high technology in central pivots in most properties (Table 2).

Table 2. Allocated Area and Total Revenue from Bean Planting.

Area (ha)	Number of Producers	%
20 to 200	21	56.76
201 to 360	10	27.03
361 to 1000	6	16.21
Total	**37**	**100.00**
Revenue Percentage		
10 to 19%	10	27.03
20 to 40%	25	67.57
40 to 60%	1	2.70
More than 60%	1	2.70
Total	**37**	**100.00**

Source: Research Data (2019).

The average age of the interviewed producers is 50 years and the standard deviation of 9.46 years, yet the average experience in bean planting is 16.54 years and the standard deviation of 8.4 years. It was found that producers with longer experience are more willing to continue the activity, despite the difficulties in marketing the product.

Experience, age range and time working with agriculture are positive factors in the adoption of more sustainable technologies, as it may indicate greater management capacity (Souza Filho et al., 2011).

The vast majority of producers employ skilled professionals such as agronomists and technicians, those having a college degree or high school, (especially those having technical education). Producers having higher level of education believe they are able to manage the activities themselves and, therefore, do not see a need to hire more specialized labor. Property management is practically familiar, performed by the owner himself or herself. When this occurs, the probability of investing in technologies is higher (Souza Filho et al., 2011). The most important data related to these variables are presented in Table 3.

Table 3. Allocated Area and Total Revenue from Bean Planting.

Variable	Number of Producers (37)	%
Age (in years)		
36 to 53	26	70.27
54 to 72	11	29.73
Level of Education		
Elementary School	04	10.81
High School	18	48.65
University Education	15	40.54
Experience Time (in years)		
1 to 10	10	27.03
11 to 20	19	51.35
21 or more	8	21.62
Employed Labor		
Agronomists	24	64.86
Agricultural Technician	08	21.62
Without Qualification	05	13.52
Property Management		
By Owner or Family	34	91.90
Professional	03	8.10

Source: Research Data (2019).

4.1.2 Technology Profile and Adoption of New Technology

Irrigated beans are present in about 70.27% of the sampled properties, which shows the great importance of the irrigated production system in the municipality of Cristalina. The preferred cultivar is Pearl and its cultivation occurs in the 3rd harvest (month of October), given the lower risk of incidence of *fusariosis*. In this harvest, the use of high technology in irrigation is characteristically remarkable because, besides being mandatory, it favors stricter pest control and a rainless harvesting (Ferreira et al., 2018). Irrigation technology is mainly via central pivot, enabling greater exploration of prices and production scheduling when the market has smaller quantities available (Ferreira et al., 2018).

The use of planting techniques is common among producers, as 94.59% do no-tillage on straw, 97.3% perform soil analysis and apply precision agriculture on their crops. All producers have a planter or combine. These data indicate the relative technological level employed in the sampled properties.

All producers use insecticide, averaging two sprays per harvest. The number of applications depends on the severity of the pests' attack. The first harvest has a yield of 32 to 52 sc. (60 kg bag)/ha, and the third from 42 to 65 sc./ha. On the other hand, the average yield of both is 50.22 sc./ha, with a standard deviation of 5.79 sc./ha. These results corroborate the findings of Silva et al. (2012) that plantings conducted in the third harvest, under irrigation, have a yield equivalent to 50 sc./ha. None of the interviewees revealed to be satisfied with the remuneration of the cultivation of beans, because it was not compensating for production costs. It was also identified that the producers surveyed have strong disposition to the planting of transgenic crops, since only one producer (2.7%) has not cultivated the crop. The synthesis of these data is presented in Table 4.

Table 4. Type and Techniques of Planting, Cultivar and Transgenic Crops

Variable	Number of Producers (37)	%
Planting Type		
Irrigated Beans	26	70.27
Not Irrigated	11	29.73
Favorite Cultivar		
Pérola – 3rd Harvest	20	54.05
BRS Estilo – 1st Harvest	10	27.03
Other Varieties	07	18.92
Techniques Employed in Planting		
No-Tillage and Land Use	35	94.60
None	02	5.40
Transgenic Crops		
Soy	4	10.81
Corn and Cotton	1	2.70
Soy and Corn	31	83.79
None	1	2.70

Source: Research Data (2019).

The data reveal that thirty-one (84%) of the interviewed producers would plant the Golden Mosaic resistant transgenic bean (cv. BRS FC401 RMD) and five (16.2%) would not. Of the former, twenty (64.4%) believe that transgenic beans could reduce pesticide use and contribute to a more sustainable agriculture. For them, the adoption of transgenic seed would contribute to reducing insecticide costs in the whitefly control, however for one producer (3.2%), this technology would not reduce the use of pesticides due to the existence of other pests and diseases that also cause serious damage to the crop, and need to be controlled with pesticides, corroborating the findings of Guivant et al. (2009).

Also among those who would plant transgenic beans, for fifteen producers (48.32%), there would be an increase in productivity, which would lead to a reduction in the area allocated for production. However, six of them (19.3%) are indifferent to this opinion, because they do not know the potential of the cultivar, and do not consider this factor relevant, since there are other cultivars with good productivity available in the market. Regarding the risk of loss, for twenty-six producers (84%) favorable to the adoption of transgenic technology, the new bean has strong potential to reduce yield losses, due to its resistance to Golden Mosaic. However, eighteen (57%) believe that the new cultivar can improve their income as they could plant beans more often during the year, thereby increasing the amount of bags to be brought to market. Nine of these producers (29%) are indifferent to this issue and one of them (3.2%) disagrees, because he/she believes that with the new technology there will be more production throughout the year, leading to greater supply and consequent price drop.

Among the potential adopters, for twenty-two producers (71%), the use of transgenic beans will reduce the problems faced with the whitefly. The others are indifferent or disagreed with that because they do not have enough information about the degree of resistance of this cultivar. These would like to test it on their crops before forming an opinion, and still believe that this bean could cause many farmers to disrespect the government policy of sanitary vacuum established for this crop. For these producers, the whitefly was not the problem in at least the last two seasons, corroborating the findings of Gonzaga et al. (2011), who also did not observe the occurrence of Golden Mosaic in the region of Cristalina, state of Goiás, Brasil, when the study was conducted. Quintela (2001) attributes this fact to the mild temperatures that occurred in the 3rd harvest, which are unfavorable to the emergence of the whitefly. Finally, among those in favor of adoption, 20 producers (64.51%) would be willing to pay 5 to 15% more for the seed of the transgenic bean, if this is compensated by the reduction of costs with insecticides.

Regarding the six producers (16%) who would not adopt the transgenic cultivar, the reasons for the denial are: i) lack of knowledge of the technical characteristics (33.3%), ii) non-acceptance of those beans by consumers due to existing controversy on the topic (16.7%), and iii) the high commercialization price of the seed (83.3%). See Table 5.

Table 5. Favorable and unfavorable percentages of the adoption of transgenic beans by Producers

Variable	Number of Producers	%
They Would Plant Transgenic Beans	**31 (84%)**	**100.0**
Reasons why they would plant		
Reduction in Pesticide Use	15	48.39
Increase in Productivity	15	48.39
Reduction in Risk of Loss	26	83.87
Income Improvement	18	58.06
Fewer Problems with Mosaic	22	70.97
Up to how much would they pay for the seed?		
Up to 5% more	5	16.13
From 5% to 15% more	20	64.52
From 16 to 25% more	06	19.35
They Would Not Plant Transgenic Beans	**06 (16%)**	**100.0**
Reasons Why They Would Not Plant		
Unknown Technical Characteristics	02	33.33
Non-Acceptance by Consumers	01	16.67
High Seed Price	05	83.33

Source: Research Data (2019).

4.2 Consumers

4.2.1 Consumer Demographics

Of the 100 consumers interviewed, it can be inferred that are typical Brazilians, consumers of common beans, predominantly women (71%), housewives, overall average age 42 years, of which 64.10% were under 50 years of age, and 80% mentioned having children. They have elementary and high school education level, 26 and 39, respectfully, of which 68% are women. Among those with college degree (34), men represent 32.4% of the total, and women, in greater numbers, are also part of the group, with lower levels of education (Table 6).

Regarding income, in this random sample, women predominate, constituting 87.5% of respondents with incomes below 3 minimum wages, and 67% of respondents, from the upper classes (income above 3 minimum wages), are men (Table 6). It is clear the predominance of women, housewives, having children, low education and income levels, constituting the typical middle-class public, consumers of common beans. It is noteworthy that the questionnaires were applied by representatives of this class, members of an Association of Housewives, from the capital. They conducted the interviews in a random form, which certainly allowed freedom of expression to those interviewed, when stating their opinions about the possible consumption of transgenic beans. See Table 6.

Table 6. Description of Demographic Characteristics of Consumers Interviewed

Category	Number (in 100)	Men (%)	Women (%)
Age (in years)			
19 to 29	29	20.70	79.30
30 to 49	39	35.90	64.10
50 to 69	26	34.61	65.39
> 70	6	-	100.0
Type of Education			
Elementary and Secondary	71	32.00	68.00
Secondary and College	29	90. 00	10.00
Level of Education			
Elementary	26	7.70	92.30
Secondary	39	38.50	61.50
College	34	32.40	67.60
No Schooling	01	-	100.0
Income			
None	5	20.00	80.00
Less than 1 minimum wage (mw)	25	12.00	88.00
Between 1 and 3 mw	40	12.50	87.50
Between 3 and 5 mw	17	58.80	41.20
More than 5 mw	13	76.90	23.10

Source: Research Data (2019).

4.2.2 Consumption Perception of Transgenic Beans

Table 7 shows that 79% of consumers would eat transgenic beans while 21% would not. Regarding the opinion of those interviewed on the possible consumption of the new transgenic beans, not only socioeconomic characteristics prevail, but above all, misinformation prevails. When asked if they have heard of transgenic foods, 57% say they are unaware of the topic, and 92% say they have little or no information about transgenic beans. Also, only 10% of those interviewed recognize the mandatory (T) symbol on the packaging, and only 10% admit to have looked for such symbol on packaging when purchasing food (Table 7).

However, 20% of those interviewed believe that transgenic beans will become a safe food. A total of 115 reasons for the consumption of transgenic beans were pointed out by them. Quality and less pesticides predominate (59%), preference for lower price (24%), experience with consumption of transgenics (20%).

Table 7. Opinion of Those Interviewed about Transgenic Beans

Question	Yes	No	Few/ Don't know	None
Have you Heard about Transgenic Food?	43	57	-	-
Do you Have Information about Transgenic Beans?	8		56	36
Do you Know about the Transgenic (T) Symbol?	10	90	-	-
Do you Consider Transgenic Beans Safe?	20	4	-	76
Would you Consume Transgenic Beans?	79	17	4	-
Reasons for the Acceptance of Transgenic Beans				
Reasons	**Quantitative**			
Has Less Pesticide	31			
Beans of Better Quality	28			
Have Already Consumed other Transgenics	20			
For Being Less Expensive	24			
Cannot Explain	12			
Reasons for Not Accepting Transgenic Beans				
Reasons	**Quantitative**			
Not Good for Health	4			
Harms the Environment	3			
Don't Have Enough Information	10			

Source: Research Data (2019).

4.3 Hypothesis Test Results

As seen in Tables 5 and 7, the proportion of "Yes" answers to the variable would transgenic beans is 84%, and for the variable would consume transgenic bean is 79%. This shows that both producers and consumers surveyed in this study are likely to adhere to the new technology of transgenic beans.

For the producers, the Likelihood Ratio test of the logistic regression model showed that three variables have statistical power to explain the variable would plant transgenic beans. The variables are: total property area (*p-value* = 0.0225), time spent working on the activity (*p-value* = 0.0033) and bean bag sale price (p-value = 0.0002).

In the case of consumers, the test indicated four variables: amount of received information (*p-value* = 0.0005), meaning of transgenic symbol (T) (p-value = 0.0188), product safety (*p-value* = 0.0276) and reasons for consumption (*p-value* = 0.0000). These variables significantly explain the variable would eat transgenic beans. The effects of explanatory variables on explained variables are shown in Table 8.

In the case of producers, the results regarding property total area and time of experience working on the activity corroborate previous studies (Keelan et al., 2009; Mwangi & Kariuki, 2015; Evans et al., 2017; Breustedt et al., 2008). The time spent working on the activity favors the development of expertise both in dealing with the risks of the conventional production and in experimenting with transgenic crops, as the data in Table 4 suggest. The total property area indicates that small farms are less likely to adhere to transgenic technology (Fernandez-Cornejo & McBride, 2002) due to not being able to bear the same level of risk that large farms can (Just et al., 1980; Feder & O'Mara, 1981). Regarding the variable bean bag sale price, the results show that bean farmers believe that reducing pesticide use, by planting transgenic beans, can increase their profits, corroborating previous reports (De Steur et al., 2019; Fernandez-Cornejo & McBride, 2002; Van Scharrel & Van der Sluis, 2004).

Table 8. Effect of Explanatory Variables on Explained Variables

Producers	
Explained Variable: would plant the transgenic bean	
Explanatory Variable	**Probability (Standard Deviation)**
Age	0.2261 (1.4649)
Person Interviewed	0.6131 (2.2557)
Access to Bank Credit	0.1275 (2.3224)
Education	0.1895 (4.6014)
Total Property Area	0.0225* (5.2040)
Time Working on the Activity	0.0033** (8.6064)
Employed Labor	0.9627 (0.0022)
Bean Bag Sale Price	0.0002*** (14.5872)
Access to Technical Assistance	0.3186 (18.9136)
Consumidores	
Explained Variable: would consume transgenic beans	
Explanatory Variable	**Probability (Standard Deviation)**
Age	0.4829 (5.4884)
Occupation	0.9253 (1.9389)
Income	0.1899 (4.7641)
Education	0.1241(4.1731)
Amount of Info Received	0.005***(15.2373)
Information Media	0.6348(4.3105)
Meaning of the Symbol (T)	0.0188* (5.5175)
Product Safety	0.0276* (4.8507)
Reasons for Consumption	0.000*** (48.0822)

Note: Prob. = probability; Std. Dev. = Standard Deviation. ***p ≤ 0.001; **p ≤ 0.01; *p ≤ 0.05; Source: Research Data (2019).

Regarding consumers, the findings show, for the four explanatory variables, that information spread by advertising campaigns about transgenic foods, especially those related to product identification and safety, positively affect the consumer's decision to buy transgenic products. Regarding the reasons for consumption despite the grouping of the 115 responses, the results show that quality aspects, less pesticides, low price and previous experience with consumption of transgenic are decisive to influence the consumer's decision to consume the new transgenic beans. These results reinforce that most Brazilians (73%) are prone to consumption of transgenic beans, and most of those (59%) not likely or undecided, would be willing to try it (Instituto Brasileiro de Opinião Pública e Estatística, 2016).

5 FINAL CONSIDERATIONS

This study provides evidence of empirical results that hopefully will contribute to the discussions about the adoption of transgenic cultivars, especially of the new BRS FC401 RMD bean developed by Embrapa. This study's objective was to identify which factors explain both the propensity of producers to plant transgenic beans and the consumers' decisions to include them in their diets. The results show positive attitudes from producers and consumers towards this new technology.

It was found that producers grow other crops besides beans and that the average area for planting beans is 232.36 ha (with standard deviation of 197.07 ha). Most producers reduced cultivating beans due to problems with the activity, among them those with the Golden Mosaic. Nevertheless, the percentage participation of bean planting in the sampled properties and their incomes is still significant. The producers have an average age of 50 years (standard deviation of 9.46 years) and average time of experience in planting beans is of 16.54 years (standard deviation of 8.4 years). Producers with longer experience time are more willing to continue in the activity, despite the difficulties of marketing the product.

The vast majority of producers employ skilled professionals such as agronomists and technicians, and who administer the property on their own. Irrigated beans are present in about 71% of the sampled properties, what shows the importance of irrigated production systems in the municipality of Cristalina. The planting of irrigated beans through central pivots, no-tillage in straw, soil analysis, insecticide applications, the use of planter and harvester, and planting of other transgenic crops are common characteristics among producers.

In this respect, there is a visible effort by Cristalina bean farmers to stay at the forefront of production technologies. This is demonstrated by the significant willingness (84% of proportion) to adopt the new transgenic bean. However, although they believe that this technology could promote improvements in disease control, the producers still lack technical and agronomical information such as those related to productivity, grain losses in storage, and bean performance in the pan. They also have questions about consumer acceptance of the product.

Total area of the property (in ha), time of experience (in years) and price of the bean bag have statistical power to explain the producers' preference to planting transgenic beans. The first two are associated with the risk level of transgenic bean cultivation. Risk is minimized on larger farms as opposed to smaller ones (Fernandez-Cornejo & McBride, 2002; Just et al., 1980; Feder & O'Mara, 1981). Yet, the time of experience working on the activity favors the development of expertise, either to deal with the risks of conventional production or to try transgenic crops. The third variable is related to higher profitability, given the possibility of reducing the cost of pesticides in the planting of transgenic beans (De Steur et al., 2019; Van Scharrel & Van der Sluis, 2004). However, it was also noticed, in the reactions of the respondents, the fear of this technology saturating the market, given that beans are a perishable, volatile product with inelastic price demand, and their market shows a clear disproportionate movement of prices to any change in the offer. In the bean market, any technology that reduces costs, increases productivity and implies greater supply will proportionally reduce the prices of the product.

Regarding consumers, the sample consists predominantly of women housewives, with an average age of 42 years, secondary level of education and income below 3 minimum wages. This is a public who characteristically consumes common bean. Despite the 79% proportion of transgenic beans consumption, corroborating research by IBOPE (Instituto Brasileiro de Opinião Pública e Estatística, 2016), consumers lack knowledge on this topic and have little to no information about transgenic beans. This shows the need to intensify the process of communication and dissemination of technical and scientific information of transgenic beans to clarify environmental and health issues of the new food.

In this regard, it is recommended to make technical-scientific communication more accessible to different audiences. The variables that significantly explain the potential consumption of the new bean cultivar are amount of information received, meaning of the symbol (T), product safety and reasons for consumption. Included in this last variable are quality aspects, less pesticides, low price and having previously consumed transgenic foods.

Although this study used non-probabilistic samples for convenience, which means that its results cannot be generalized beyond the investigated public, the evidence identified here will hopefully serve as input for further research advancement of this topic. Relevant aspects to be further investigated in explaining the adoption of (i.e., preference for) transgenic cultivars relate to the qualification and availability of credit to farmers (Feder et al., 1985; Souza Filho et al., 2011).

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