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Article

# Socioeconomic impact of Covid-19 on the agricultural and agroforestry systems of Irrigation District 005, Chihuahua.

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## Abstract

In 2019, a virus of unknown etiology appeared in Wuhan, China, causing acute pneumonia in the human population, spreading rapidly in the world; therefore, the World Health Organization declared a pandemic. The research aimed to evaluate the socioeconomic impact that the Covid-19 pandemic had on the producers of the agricultural and agroforestry systems of the Irrigation District 005 Delicias, Chihuahua, Mexico. Data collection was through direct and electronic surveys via Google forms to agricultural and pecan (*Carya illinoinensis*) producers as an agroforestry system. Chi-squared, absolute frequency, relative frequency, and significance level analyses were performed. The results indicated that 49% considered that their productive activity was affected by the Covid-19 pandemic; 28.1% indicated that there were problems in obtaining labor because people who came from outside the state did not show up to work; 20.8%indicated that the carriers increased their prices and stopped their activities for short periods; 37.5% indicated that the price of inputs increased by more than 30% from their usual price; 35.4% indicated a decrease in production because fewer inputs were applied to the soil; 48.4%mentioned that sales decreased by 5% to 10%. Compared to the impact on other agroforestry systems in different parts of Latin America, Irrigation District 005 was impacted socially and economically in terms of labor shortages, transportation problems, price increases, and input shortages.

## Keywords:

coronavirus, economy, pandemic, productive impact.

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## Introduction

Multiple factors, such as social, political, economic, environmental, and even health problems, can give rise to a food crisis. In 2019, at the end of December, cases of pneumonia of unknown etiology were found in the city of Wuhan, China (Zhu *et al*., 2019). The causative agent was severe acute respiratory syndrome coronavirus 2 (Sars-CoV-2) (Krammer, 2020).

Due to the rapid spread of the virus, the World Health Organization (WHO) had to declare a global pandemic. On February 27, 2020, the first positive case of Covid-19 was detected in Mexico (Secretaría de Salud, 2020a). In each country, contingency measures had to be taken to prevent the spread of the virus. In Mexico, on March 23, the Secretariat of Health (SS, for its initialism in Spanish) decreed a health emergency in the Official Gazette of the Federation (DOF, for its acronym in Spanish) in addition to establishing preventive measures for the mitigation and control of this disease through the 'national campaign of healthy distance', which lasted from March 30 to April 30 of the same year.

Mandatory quarantine would imply the temporary suspension of non-essential activities that involved physical concentration, transit, or movement of people to prevent the spread of the SARS-CoV-2 virus (Secretaría de Salud, 2020b). Given the different contingency measures that countries adopted, the Inter-American Institute for Cooperation on Agriculture (IICA, 2020) stated that the pandemic caused by the SARS-CoV-2 virus would be capable of triggering a crisis in prices and supply and product distribution problems.

This was because trade, agriculture, livestock farming, and agroforestry were not being carried out conventionally as many countries closed their borders, causing an overload of the supply chain to the detriment of farmers, traders, and carriers (Vieira, 2020). In this context and for a better understanding, agricultural systems are focused on intensive production, obtaining high yields per unit of area with the aim of increasing and providing food to the population (Gutiérrez *et al*., 2015).

Likewise, agroforestry systems (AFS) involve forest trees, agricultural crops, and silvopastoral spaces (Schoeneberger 2009; Sauer and Hernández-Ramírez 2011). These systems carry out preservation and production in forest, woody, and perennial components (Casas *et al*., 1997, 2007); they also manage agricultural elements with perennial or annual plants, cultivated and domesticated; there are social production units that manage the different components to maximize the ecological interactions between the forest and agricultural elements of the system within a particular ecological, cultural, and economic context (Nair, 1997).

In this regard, the main crops in the Irrigation District (DR 005, for its initialism in Spanish) are green forage corn (*Zea mays*), alfalfa (*Medicago sativa*), green chili (*Capsicum annuum* L.), peanut (*Arachis hypogaea* L.), pecan trees (*Carya illinoinensis*), watermelon (*Citrullus lanatus*), onion (*Allium cepa*), and cotton (*Gossypium hirsutum*) (CONAGUA, 2016).

Considering the above, in general, producers combine the use of the soil of their plots by distributing planting and production according to the needs of the market and consumption to improve their economy; these may have blocks of chili (*Capsicum annuum* L.), watermelon (*Citrullus lanatus*), pecan tree (*Carya illinoinensis*) or corn (*Zea mays*), alfalfa (*Medicago sativa*), and pecan tree (*Carya illinoinensis*); another variant observed is alfalfa (*Medicago sativa*), onion (*Allium cepa*) and for agroforestry systems, in the alleys of pecan (*Carya illinoinensis*) plantations, producers sow clover (*Trifolium repens* L.), oats (*Avena sativa*) for sheep grazing, and barley (*Hordeum vulgare*), the production of which is for the brewing company Heineken Mexico, in Meoqui, Chihuahua. More recently, sotol (*Dasylirion* spp.) plantations, coriander (*Coriandrum sativum* L.), and oregano (*Origanum vulgare* L.) as a non-timber forest product, being a species native to the Chihuahuan Desert, have been established in the center of young pecan plantations.

The above is fully compatible to be called and assumed as an agroforestry system typical of DR 005 in northern Mexico. The objective was to evaluate the impact that the Sars-CoV-2 or Covid-19 pandemic had economically and socially on the agricultural and agroforestry systems of Irrigation District 005, Chihuahua, Mexico.

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The hypothesis was that Covid-19 had a negative impact at the social and economic levels on the agricultural and agroforestry systems of DR 005, Chihuahua, Mexico. The scope of the study was regional.

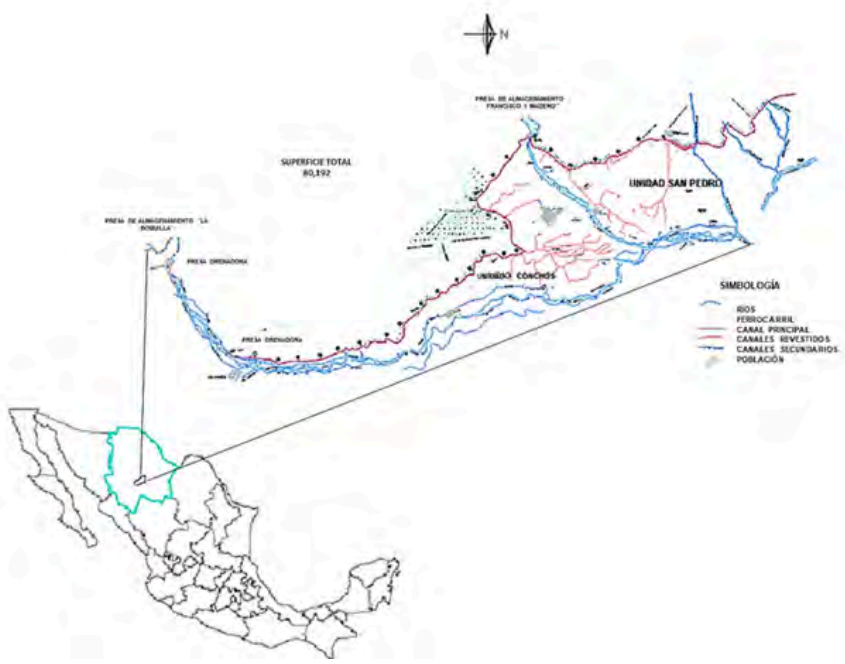
# Materials and methods

## Location of the study area

The study area is located in DR 005 in the state of Chihuahua in the south-central region within Hydrological Region 24 (RH 24, for its initialism in Spanish) (IMTA, 2013). Its coordinates are 27° 31' to 28° 35' north latitude and 105° 45' to 105° 00' west longitude (CNA, 2002). In the irrigation area of the irrigation district, the average annual rainfall is 334.1 mm (IMTA, 2013).

The climate is extremely dry, semi-warm BWh' (h), dry semi-warm BSoh' (h), and semi-dry temperate BS1k' (h) with rainfall in summer and average annual temperatures between 12 and 18 °C, average temperatures of the coldest month between -3 °C to 18 °C, and total annual rainfall between 300 to 500 mm (Figure 1); the soils are mainly regosol (INEGI, 2005). It has an irrigated area of 61 443.1 ha and a distributed volume of 884 856.1 thousand $m^3$ (CONAGUA, 2016).

**Figure 1. Geographical location of Irrigation District 005, Delicias, Chihuahua, modified from Ortega (2012).**




## Sampling

In this research, the sampled population were producers who had established blocks and divisions of agricultural and agroforestry crops on their plots. According to Otzen and Manterola (2017), the type of sampling applied was simple random sampling for a proportion, in which the individuals that make up a population have an equal probability of being chosen.

This type of sampling is used when the study population is large and makes it easier to analyze the data. The sample size was obtained using the formula proposed by Fisher and Navarro (1996).

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$$n=\frac{NZ^2pq}{e^2(N-1)+Z^2pq}$$

Where: n= sample size; N= total population; $Z^2$= confidence level; *p*= probability of success; q= probability of failure; $e^2$= estimation error.

## Survey design and data collection

Data were collected through electronic surveys via Googe forms and face-to-face surveys of farmers who have established plantations and production of pecan trees (*Carya illinoinensis*) on their plots and are registered in the DR 005 producer registry.

## Method

Fifteen categorical variables, divided into social and economic, were considered. Among them were the spread of Covid-19 in work groups, the availability of products and accessories to comply with sanitary measures, the impact on productive activity due to the Covid-19 pandemic, transportation problems and ways to deal with the crisis (use of savings, loan applications, and sale of assets), among others. These variables were analyzed using the statistical software of R 4.2.2 (R Core Team, 2022). Analyses of chi-square, absolute frequency, and relative frequency were performed to analyze the results obtained in each question of the survey applied.

# Results and discussion

## Sampling

According to the type of sampling carried out, the sample size was determined with the formula proposed by Fisher and Navarro (1996). The following values were considered for this research: N= 8 113 (CONAGUA, 2021); Z= 1.96 (95%); d= 0.1; *p*= 0.5; q= 0.5.

$$n=\frac{(8113)(1.96)^2(0.5)(0.5)}{(0.10)^2(8113-1)+(1.96)\text{^}2\ \ (0.5)(0.5)}=95$$

The formula yielded a sample size of 95 producers who, in their plots, have established blocks or divisions of agricultural and agroforestry crops; the latter represented by pecan trees (*Carya illinoinensis*) in combination with other crops, such as clover (*Trifolium repens* L.), oats (*Avena sativa*), and barley (*Hordeum vulgare*), among others.

## Social variables of DR 005

### Spread of Covid-19 in work groups

Sixty point four percent [$X^2$ (2, 31.94) $p< 0.001$] of the producers in the agricultural and agroforestry systems in the sample had no records of virus spread in their employees. Nonetheless, 21.9% [X2, 31.94) $p< 0.001$] of the respondents were infected with Covid-19 and 17.7% [$X^2$ (2, 31.94) $p< 0.001$] reported infections among their workforce.

In contrast, Martínez *et al*. (2021) report that, in the agricultural area of Guanajuato, Mexico, 22% were infected with the virus. At the international level, Alvarez *et al*. (2020) indicated that, in Colombia, Honduras and Guatemala, in most producers, the symptoms of Covid-19 were limited.

## Availability of products and accessories to comply with sanitary measures

Forty-four point two percent of the producers of the agroforestry systems consulted indicated [$X^2$ (3, 21.59) $p< 0.001$] that their employees had the basic products and accessories (antibacterial gel and face masks) to respect the decreed measures and prevent the spread of the virus within the work groups and teams. IICA et al. (2020) point out that, in Latin America and the Caribbean, 50%of the farmers in their sample were highly affected by the lack of protective equipment and the lack of sanitary protocols.

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These simple measures, although they may seem easy, were responsible for significantly preventing the spread of the virus. However, there were people who, despite the fact that the measures were established by the health authorities, did not respect them, evidencing a very deficient culture in relation to health care.

## Respect for sanitary measures

Forty-nine percent [$X^2$ (3, 31.25) $p< 0.001$] of the sample of producers indicated that their employees obeyed all the established measures but only at the beginning of the pandemic for fear of contagion, and a short time later, only some continued to respect them. In this regard, it is important to implement training courses or campaigns to raise awareness among producers of agricultural systems and producers of pecan trees (*Carya illinoinensis*) (agroforestry system), as well as their employees, regarding the importance of complying with the sanitary measures established by the authorities to protect themselves from Covid-19 or any other disease that may arise in the future, and with this, the food production and supply chain is strengthened in the face of any type of accident or contingency.

## Strategies for sanitary measures for the mitigation of the adverse effects of the pandemic by producers

Thirty-seven point five percent [$X^2$ (4, 47.96) $p< 0.001$] of the producers of the agricultural and agroforestry systems consulted recommended that all sanitary measures, established by the health authorities, be correctly respected within the agricultural area and agroforestry systems. Likewise, 36.5% [$X^2$ (4, 47.96) $p< 0.001$] of the interviewees indicated that if there had been vaccines in a timely manner for farm workers, infections and the negative effects of the pandemic would have been reduced.

Additionally, 13.5% [$X^2$ (4, 47.96) $p< 0.001$] stated that the government should have provided face masks and gel for field workers, 7.3% [$X^2$ (4, 47.96) $p< 0.001$] mentioned having informative talks by the authorities to producers of agricultural and agroforestry systems as a measure, and 5.2% [$X^2$ (4, 47.96) $p< 0.001$] said that it would have been pertinent to conduct Covid-19 testing for workers in agricultural systems and agroforestry systems.

In this regard, in their study in Latin America and the Caribbean, IICA *et al*. (2020) mention that 53% of the sample recommend following health protection protocols to the letter and having the necessary safety equipment to avoid contagion of producers and their employees. The measures recommended by the producers of the agricultural and agroforestry systems are relevant since they originate in the main actors who serve as workers in the aforementioned systems.

## Strategies for operational measures for the mitigation of the adverse effects of the pandemic by producers

Twenty-seven point one percent of the producers of the agricultural and agroforestry systems surveyed [$X^2$(3, 1.42) $p> 0.05$] indicated that, in the face of this type of crisis, other alternatives should be sought for the transport of personnel to keep a healthy distance and avoid overcrowding and in the case of goods, avoid large volumes of products that could be contaminated by the virus. Also, 26% [$X^2$ (3, 1.42) $p> 0.05$] mentioned that it was desirable that they had not closed the borders or supply centers as an operational measure.

Additionally, 19.8% [$X^2$ (3, 1.42) $p> 0.05$] of the producers reported, as an operational measure, that there had been greater market flow; finally, the other 27.1% [$X^2$ (3, 1.42) $p> 0.05$] of the sample indicated that, because everything went normally operationally, they did not have any recommendation. Nevertheless, the recommendations given by the respondents should be considered for future crises that may arise.

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## Economic variables of DR 005

### Main crop during the year

In the DR in question, the main crops reported by the surveyed producers of the agricultural and agroforestry systems were alfalfa (*Medicago sativa*) and pecan trees (*Carya illinoinensis*) with 39.6% and 27.1% [$X^2$ (7, 105.67) $p< 0.001$], respectively. Similarly, Lucero *et al*. (2022) pointed out that, in their sample of producers in irrigation district 005, 65.62% plant mainly pecan trees (*Carya illinoinensis*) and 21.05% have alfalfa (*Medicago sativa*) as their main crop.

## Impact on productive activity due to the Covid-19 pandemic

Forty-nine percent [$X^2$ (3, 31.92) $p< 0.001$] of the respondents considered that their productive activity was affected by the Covid-19 pandemic because input prices increased and there was a shortage of these. In Latin America and the Caribbean, IICA *et al*. (2020) reported that more than 50% of the farmers interviewed were affected regarding safety protocols for workers, protective equipment, transportation of products, limitation of product distribution, and limitations on access to financial capital.

Additionally, Álvarez *et al*. (2020) pointed out that, in Colombia, Guatemala and Honduras, between 68% and 75% of the farmers in their sample experienced negative effects on their productive activity due to the pandemic, such as a decrease in resources to invest in agricultural activities, limited access to inputs and seeds, and difficulties in bringing their products to market. What was reported by the producers indicates the negative effects that agri-food production suffered due to the pandemic

## Suspension of activities

In DR 005, 41.7% [$X^2$ (3, 33.75) $p< 0.001$)] of the surveyed producers of the agricultural and agroforestry systems did not suspend their activities during the mandatory quarantine or during the course of the pandemic, stating that the productive process of the countryside had to continue. Likewise, Gómez and Posada (2021) report that, in the locality of La Isla in the municipality of Funza, department of Cudinamarca, in Colombia, only 19% of the farmers surveyed stopped their activities.

This coincides with Álvarez *et al*. (2020), who indicated that, in Colombia, Honduras, and Guatemala, farmers did not stop their activities; however, 96% had to work less due to the measures established. In this regard, the commitment of producers in agricultural and agroforestry systems to the work in DR 005, as well as the commitment of other producers from different latitudes, mitigated food shortages and, with constant work, strengthened agri-food chains, which showed elements of resilience in the face of the pandemic.

## Percentage decrease in production

Thirty-five point four percent [$X^2$ (3, 28.82) $p< 0.001$] of producers of agricultural and agroforestry systems, of the sample of the referred district, indicated that there was a decrease in their production due to the fact that fewer inputs were applied to the land. The decrease in their production was around 5% to 10%. Although the decrease could be considered small, they said that this percentage is significant for them in relation to a high volume of production, and this considerably affects the income from the sale of the harvested products.

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## Labor

Thirty-nine point six percent [$X^2$ (3, 14.75) $p< 0.01$] of the producers of the agricultural and agroforestry systems mentioned that, with respect to labor, they did not have any problem because they continued with their usual employees. On the other hand, 28.1% [$X^2$ (3, 14.75) $p< 0.01$] indicated that they did have to deal with this problem since people who came from outside the state did not show up for work and they also have problems with personnel transportation. In accordance with the above, IICA *et al*. (2020) pointed out that only 36% of their respondents presented this problem in agricultural areas.

Álvarez (2020) also reported that, in Colombia and Guatemala, for the interviewees, it was more difficult for them to find labor since the beginning of the pandemic. In Honduras, on the other hand, 44% of those surveyed did not have problems finding labor. Similarly, in phase 1 of their study, Salazar *et al*. (2020) found that 40% of their interviewed producers had difficulties in obtaining external labor; that figure increased over the course of the pandemic to 51.4% during phase 2 of Salazar *et al*. (2021) study. The above problem could have been caused by people's fear of contagion of the disease, restrictions on movement, and contingency measures.

## Transportation issues

About 43.8% [$X^2$(3, 18.33) $p< 0.001$] of the respondents did not present problems with the transportation of the products in DR 005. Nonetheless, 20.8% [$X^2$ (3, 18.33) $p< 0.001$] of the producers of the agricultural and agroforestry systems commented that they did have this problem because the carriers increased their prices and stopped their activities in short periods. Conversely, in Latin America and the Caribbean, IICA (2020) found that 50% of their respondents had problems distributing and transporting their products in the first three months of the pandemic.

In Guanajuato, Mexico, Martínez *et al*. (2021) reported problems related to the distribution and acquisition of goods in 40% of the farmers in the sample. In phase 1, Salazar *et al*. (2020) found that 69% of producers presented this problem; during phase 2, Salazar *et al*. (2020) indicated an improvement, as this percentage decreased to 56%.

Works such as that by Álvarez *et al*. (2020) documented that, in Colombia, Guatemala and Honduras, 70% of agricultural producers had problems transporting their crops; they also pointed out that 86% were due to lack of service and 19% because there was an increase in service prices. The aforementioned studies showed that the pandemic had economic effects on the transport of goods from the agricultural sector and agroforestry systems, mainly due to the increase in prices in the transport of products.

## Increase in the price of inputs

According to 37.5% [$X^2$ (3, 14.09) $p< 0.01$] of producers in agricultural and agroforestry systems, the prices of inputs, such as fertilizers, seeds, fungicides, insecticides, herbicides, and fuels, increased by more than 30% from their usual price. Forty-seven point eight percent [$X^2$ (2, 9.27) $p< 0.01$] of the surveyed producers of the agricultural and agroforestry systems attribute the increase in price to the shortage of inputs caused by the Covid-19 pandemic. Similarly, IICA (2020) mentioned a 40%increase in the price at which inputs are usually found.

This shows that this problem did not only occur in DR 005 but also in Latin America and the Caribbean. According to 48.9% [$X^2$ (12, 239.91) $p< 0.001$] of the producers in the sample, fertilizers, seeds, fungicides, insecticides, herbicides, and fuels increased their usual price by 30%. Salazar *et al*. (2020, 2021) reported results that are similar to those of this study in 90% of their respondents. Similarly, Martínez *et al*. (2021) indicate that, in Guanajuato, Mexico, 90% of their respondents indicated that the prices of fertilizers increased by 300%.

In Latin America and the Caribbean, IICA (2020) indicated that 28% of the farmers in the sample mentioned increases in prices of agrochemicals and seeds. According to the above, food security could be threatened in the short and medium term due to the negative effects of prices on productive

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agricultural systems at the regional level. Therefore, it is very important that there are state public policies to mitigate such a situation at the national level.

## Percentage by which sales decreased

Forty-eight point four percent [ ($^2$ (2, 15.32) $p< 0.01$)] of the producers mentioned that the sales of their products decreased by 5% to 10%. Although they considered the percentage to be a small figure, they said that it directly led to lower income, surplus value and profit derived from the harvested products. Ninety-three point five percent [$X^2$ (2, 50.58) $p< 0.001$)] of the producers who presented a decrease in their sales indicated that the main cause of impact on the sale of the harvest was the decrease in demand. In contrast, Salazar *et al*. (2020, 2021) pointed out that 70%of the producers in the sample, in Argentina, Bolivia, Paraguay, Peru and the Dominican Republic, mentioned that the sale of their crop was affected by the difficulty of transporting it.

## Ways to cope with the crisis (use of savings, applying for loans, and selling assets)

Forty-two point one percent [$X^2$ (2, 3.68) $p> 0.05$] of the producers of the agricultural and agroforestry systems in the sample were not economically affected by Covid-19. For this reason, they did not have to resort to using savings, applying for loans, and selling assets to cover the expenses of their planting. Nevertheless, 31.6% [$X^2$ (2, 3.68) $p> 0.05$] did use these measures to deal with the crisis. On the contrary, Álvarez *et al*. (2020) found that, in Honduras, 40% of respondents applied for a loan or used their savings to carry out agricultural activities.

Likewise, Salazar *et al*. (2020, 2021) reported that 70% of their sample did have to take any of these measures to face the crisis. This showed that producers have a great commitment, respect for the countryside, and a marked responsibility for food security for the population.

## Strategies for economic measures for the mitigation of the adverse effects of the pandemic by producers

The economic measures recommended by 44.8%;$X^2$ [2, 6.94) $p< 0.05$] of the surveyed producers of the agricultural and agroforestry systems are the re-implementation of support programs for the agricultural sector, such as PROCAMPO, and other support programs that benefit farmers.

Thirty-two point three percent [$X^2$ (2, 6.94) $p< 0.05$] of the producers in the sample mentioned economic support for the purchase of agricultural inputs as a measure; finally, 22.9% [$X^2$ (2, 6.94) $p< 0.05$] indicated that, in the face of crises such as the one that has occurred, taxes on farmers should be reduced. In this sense, Salazar *et al*. (2020) mention the importance of public policies that increase the liquidity of producers to maintain their activities in the face of this type of crisis.

As an example, they also mention several countries such as Paraguay, in which farmers were supplied with inputs and seed kits; similarly, in the Dominican Republic and Peru, rural bonuses were granted to producers. In the face of this type of crisis, it is worth emphasizing that the producers of Irrigation District 005 need economic support to guarantee food security, not only at the regional level but also at the national and international levels. The economic variables provided an overview of the main economic characteristics of the agricultural and agroforestry sectors of DR 005 and its current situation. Overall, they indicated that these sectors were affected economically.

# Conclusions

In Irrigation District 005, the major impacts occurred in the first months of the health crisis, in terms of shortages of inputs, increase in their price, labor shortages, and transportation problems. In general, Irrigation District 005 remained strong; however, between 40 and 45% of the producers surveyed were socially and economically affected by Covid-19. Compared to other producers in Latin America, the impact was moderate.

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The commitment and strength of the producers, in their agricultural and agroforestry systems, allowed them to be resistant and resilient in the face of adversity and they continued their work in the field despite the risks they faced and thanks to the hard work, food sovereignty was not harmed, maintaining supply chains in terms of agri-food production in the agricultural and agroforestry systems of Irrigation District 005.

The Sars-CoV2 or Covid-19 pandemic had socioeconomic effects; nevertheless, it is also a learning opportunity for producers, which allows them to carry out, in their agricultural and agroforestry systems, a comprehensive restructuring and prepare for any other situation of this type, being able to face it with better elements of resistance and resilience in various aspects, including social, economic, human, and productive, without neglecting those of a health nature in the context of a new normality that may increasingly be threatened by possible future pandemics.

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