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Article

Situation of cotton production in La Comarca Lagunera

Ignacio Orona-Castillo[1]
Cirilo Vázquez-Vázquez[1]
Dora Ma. Sangerman-Jarquín[2,§]
José de Jesús Espinoza-Arellano[3]
Apolinar González-Mancilla[1]

1 Facultad de Agricultura y Zootecnia-Universidad Juárez del Estado de Durango. Carretera Gómez Palacio-Tlahualilo km 28, Ejido Venecia, Durango. Tel. 871 7118918. (orokaz@yahoo.com; cirvaz60@hotmail.com; apolinar.gonzalez@ujed.mx).

2 Campo Experimental Valle de México-INIFAP. Carretera Los Reyes-Texcoco km 13.5, Coatlinchan, Texcoco, Estado de México. AP. 10. CP. 56250. Tel. y Fax. 595 9212681 y 595 9212698, ext. 128 y 137.

3 Universidad Autónoma de Coahuila. Boulevard Revolución 151 Oriente, Torreón, Coahuila. CP. 27000. Tel. 871 7128044. (jesusespinoza-612@yahoo.com.mx).

Autora para correspondencia: sangerman.dora@inifap.gob.mx.

Abstract

In Mexico, cotton is sown to obtain fiber for the textile industry. Nonetheless, it is also one of the five main crops of importance in the production of vegetable oils. La Comarca Lagunera has been characterized as a traditionally cotton-growing area; however, the crop has lost importance due to the little support it receives and in recent years (2005-2021), the sown area decreased 37.3% and production has been concentrated in the municipalities of San Pedro de las Colonias and Francisco I. Madero. The objective of this study was to characterize the cotton production system in this area. It was hypothesized that producers with larger areas obtain higher yields. To calculate the sample, the register of producers was used and a sample of 80 was determined with simple random sampling at a confidence level of 95%. The information was collected through a survey that included technical and socioeconomic aspects and the survey was carried out from July 2022 to January 2023. The results showed that producers with larger areas are younger, have a better educational level, obtain higher yields, and that the greater the area sown, the higher the rent of land and water. It is concluded that cotton cultivation in La Comarca Lagunera requires supportive public policies to remain.

Keywords:

land and water rent, pests and diseases, production technology.

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Introduction

Worldwide, in the 2016 cycle, cotton ranked third in terms of sown area within oilseed crops and fourth in terms of oil production, only surpassed by soybeans. Nevertheless, despite its limited share in oil production, it remains the main producing crop of natural fibers (FAOSTAT, 2018). In the 2010-2022 period, the area sown with cotton worldwide averaged 33 million hectares and reached a production of 73.4 million tons of seed cotton, a yield of 2 t ha^{-1} a of seed cotton and 657 kg of cotton lint.

In the last 40 years, the area sown with cotton has remained with very little variation; however, it has been observed that the production of seed cotton increases year by year due to the fact that it has been possible to increase the unit yield significantly, which managed to increase from 1.1 t ha^{-1} in 1976 to 2.6 t ha^{-1} in the 2020 cycle, which represented a 136% net increase; this trend in yield is attributed to the growing use and release of transgenic varieties with greater productive potential (Ávila *et al*., 2023).

According to SAGARPA-FAO (2014), Bt cotton was first planted for commercial purposes in 1996 in Australia and the United States of America. The benefit of using transgenic cotton is mainly expressed in the reduction of the use of insecticides for pest control and in obtaining higher yields. Cotton planting in Mexico has experienced a gradual decline since, at the beginning of the 70's, around 500 000 ha of cotton were sown, it was considered that 90% of its production came from irrigated sowing.

In the last twenty years, the crop has gone through a stage of crisis like other crops, mainly due to the low prices with which they have been quoted in the international market, coupled with problems in the control of pests, such as boll weevil (*Anthonomus grandis* Boheman), pink bollworm (*Pectinophora gossypiella* Saunders) and in the 1994-1996 cycles, the presence of the whitefly (*Bemisia tabaci*, Gennadius), which increased production costs and caused some producers to be decapitalized (Ávila *et al*., 2023).

The situation described has led to the abandonment of the crop by small producers and the concentration of water and land in producers with sufficient economic capacity to continue. From the 1995 cycle, a small recovery can be observed, increasing its sowing and production, although erratically, it is significant (Ávila *et al*., 2023).

In 1996, the Mexican government approved the introduction of biotechnology in cotton, so the sowing of genetically modified (GM) seeds with resistance to pink bollworm began (Salgado, 2009; Traxler *et al*., 2003). With the introduction of GM cotton seeds, the average yield of seed cotton per ha increased significantly, from 3 t in 1996 to 4.28 t in 2015 (SIAP, 2015).

Studies conducted by Palomo *et al*. (2003) argue that the increase in yields in La Comarca Lagunera was due not only to transgenic seeds but also to the application of a technological package generated by INIFAP Laguna that included sowing in narrow furrows, three supplemental irrigations, and high plant population densities.

Currently, year after year, it is required to import this fiber since national production fails to meet demand; in the 2019 cycle, a total of 916 984 t of seed cotton were produced, which represented a total of 1 417 158 bales, with a domestic consumption of 1 925 million bales, where only 850 000 bales were imported this year (indexmundi, 2018).

In the 2022 agricultural cycle, 157 993 ha were harvested in Mexico, where the state of Chihuahua was the one that sown the most, participating with 118 059 ha, followed by Baja California Norte with 13 522 ha, Coahuila with 11 391 ha, Tamaulipas with 10 847 ha, Sonora with 2 635 ha and Durango with 1 539 ha. In terms of yield in this cycle, Coahuila obtained the highest yield with 5.509 t ha^{-1} of seed cotton, followed by Chihuahua and Durango with 5.471 and 5.208 t ha^{-1} respectively (SIAP, 2023).

La Comarca Lagunera has always been characterized by being a cotton-growing area; nonetheless, the area allocated to the crop has decreased since the end of the 90's due to high production costs and the volatile international price of fiber. This has led to the gradual abandonment of the crop

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by producers and the concentration of land and water in producers with high financial capacity. In 2005, it was sown in ten municipalities and in 2021, only in five, of which 82% of the area was concentrated in the municipalities of Francisco I. Madero and San Pedro de las Colonias, Coahuila.

Based on the statistical data reported by SAGDR (2022), the area sown and harvested in this region in the 2005-2021 period decreased by 37.3%, while production decreased by 35.3%, a situation that motivated us to carry out this study. The objective was to characterize the cotton production system and, through a stratification of producers, to identify the differences in yields and phytosanitary problems to determine the level of production obtained by strata of producers and phytosanitary problems they face in their crops, hypothesizing that producers with a larger cotton area obtain higher yields and that greater areas sown with cotton are possible due to the existence of rent of land and water rights.

Materials and methods

The study area is included in the region called Comarca Lagunera, located in north-central Mexico, considered an agricultural and industrial zone located between the meridians 102° 50' and 103° 40' west longitude and parallels 25° 25' and 26° 30' north latitude, in the states of Durango and Coahuila. The climate of this area, according to the Köppen classification modified by Enriqueta García (Cháirez and Palerm, 2013), corresponds to BWhw" (e'), which is characterized by being very dry or desert, semi-warm with a cool winter, with an average annual temperature between 18 and 22 °C, and the coldest month less than 18 °C, with an average rainfall of 250 mm, and a potential evaporation of the order of 2 500 mm per year.

To carry out this study, we used the registry of cotton producers of La Comarca Lagunera in the offices of the Local Board of Plant Health located in the Municipality of San Pedro de las Colonias, Coahuila. The study focused on ginning plants located in the municipalities of Francisco I. Madero and San Pedro de las Colonias, Coahuila, which concentrated 83% of the area sown with cotton in 2022.

From a sample universe of 580 cotton producers, registered in ginning plants located in the municipalities of Francisco I. Madero and San Pedro de las Colonias, Coahuila, the sample size was determined by applying the following statistical formula provided by Stephen and William (1996), where a sample size of 80 producers was estimated:

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

Where: n= is the size of the population sample to be obtained; N= is the size of the total population; e= represents the standard deviation of the population, which in this case is equivalent to 0.5; Z= is the value at a confidence level of 95%, the minimum accepted value to consider the research as reliable; e= represents the acceptable limit of sampling error, in this case it was 7%.

After calculating the sample size, the sample was divided into three strata to characterize the producers: the first included those who sowed up to 5 ha, identified as small producers; the second those who sowed between 5.1 and 25 ha, who were called medium-sized producers and the third group included producers with areas greater than 25 ha, who were called large producers.

According to this criterion, 35% of cotton producers are classified as small, 40% as medium and 25% as large producers. The data were obtained from a survey made up of 41 questions answered by the owners of the cotton production units; this survey contained information on technical aspects of the crop and aspects of organization and support to the producer.

This stage lasted from July 2022 to January 2023. Once the information in the questionnaires was reviewed, it was captured using the Microsoft Excel program, where it was processed for analysis. This tool was used to calculate the values of the technical and socioeconomic variables at the global level for each of the production units and for each of the defined strata of producers, for the corresponding comparative analysis.

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Results and discussion

Producer's age

The average age identified among those engaged in this crop was to 56 years, with a minimum age of 26 years and a maximum of 85. In the case of small, medium and large producers, the average was 61, 57, and 50 years old, respectively; it is highlighted that large producers are younger in general.

In a study carried out by Ávila *et al*. (2017) for La Comarca Lagunera, the average age of producers engaged in cotton was 60.4 years and the minimum was 31; according to this, the older producers have been withdrawing from the crop and younger people are entering as producers, since for 2021, the youngest age reported is 26 years.

Number of years spent growing cotton

At the Comarca Lagunera level, the average number of years they have spent in cotton cultivation is 27, the extreme values for this variable were one and 70 years. The average value of this indicator decreases as the area sown with cotton increases, so that it was 29, 27, and 25 years for small, medium, and large producers, respectively, which indicates that small producers are the ones with the longest time in cultivation.

In this regard, in a study carried out by FAO (2016), it was found that for Bolivia, more than half of cotton producers have spent more than 20 years on the crop and only 19% have spent less than five years. In La Comarca Lagunera, only 8% of producers have spent up to five years on the crop and 60% more than 20 years, a situation similar to that of Bolivia.

Educational level of cotton farmers

The study found that the prevalent level of education at the global level is elementary education, with 31% of producers. It is noteworthy that four out of ten producers have a level of education higher than high school, where the largest proportion are graduates in the area of agronomy.

Of small and medium-sized producers, 39 and 34% of them have elementary education. The sector with the highest proportion of producers with the best level of education is located in large producers, as 40% of them have a bachelor's degree.

Financing cotton production

The proportion of producers who did not receive financing for the crop in the 2021 cycle was 14, 19, and 25% for small, medium, and large producers, respectively. The rest used their own resources or through the ginning plant to which they are affiliated, where the larger the area size, the more they do without this support.

The financing they receive through the ginning plant is delivered to the producer according to how it is required and since it is here where they gin, pack, and store the cotton, once they sell it, they pay the loan obtained.

Regarding the issue of financing for cotton producers, for 2020, in the Argentina Republic, the Argentine online newspaper Infobae (2020) reported that 50% of the area sown with the crop required it to finish their harvest, which indicates that there is better support in this area for producers in La Comarca Lagunera than for those producers.

Transgenic seeds used in cotton sowing

The cotton sown in La Comarca Lagunera is with genetically modified seed; the producers sow a certain area on the edges of their plot with non-transgenic cotton varieties that serve as refuge plants for the species of insects affected by genetically modified organisms.

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This regional production system is identified with the one described by SAGARPA-FAO (2014) as a high-density production system, which uses high-precision machinery for sowing and fertilization (it helps to reduce the amount of fertilizer and make better use of water) and genetically modified organisms (GMOs) (*Gossypium hirsutum* L.). The ginning plants to which the producers are affiliated provide all these facilitations. The transgenic seeds identified in the study were the following: Deltapine 0912, 2020, 1820, 0918, and Fibermax 2484, where P 0912 predominates (Table 1).

Table 1. Proportion of producers who sowed transgenic cotton seed by type of producer in La Comarca Lagunera.

Type of seed	Global	Small	Medium	Large
Deltapine 2020	20	4	19	45
Deltapine 0912	40	25	63	25
Bayer 1820	25	50	9	15
Deltapine 0918	11	18	9	5
Fiber Max 2484 Bt	4	4	0	10

The seed most used by small producers was Bayer 1820, Deltapine 0912 by medium-sized producers and Deltapine 2020 by large producers. The source of seed supply is the ginning plant to which they are affiliated. The agricultural cooperative a private company in the region, is the one that provides the ginning plant with seed, agrochemicals, and other inputs necessary for the crop.

However, the use of transgenic seed generates a dependence on the private biotechnology company that developed the seed since it is the owner of the inserted genes; in this way, when the farmers pay for the seed, a percentage of the cost is for the intellectual property and goes to the company that developed it.

Cotton losses at harvest

According to the information provided by the surveyed producers, 98% of them harvest their cotton mechanically; at a global level, the loss of seed cotton at the time of harvest amounts to 7% of the total, which would be equivalent to 400 kg of the average yield per hectare, which is 5 726 kg.

When considering the average yields by stratum, the losses were estimated at 364, 497 and 290 kg of seed cotton for small, medium, and large producers, respectively; they occur due to the poor calibration of the harvesters and the reason for not picking the cotton that remains in the field is because more is paid for its harvest manually than what would be obtained by its sale.

In addition, since there is no difference in the price, they receive for cotton harvested mechanically and manually, manual harvesting is not encouraged. For this reason, the saying that 'cotton cultivation is of social importance because it generates many jobs in the cotton harvest' is over. Amanecer rural (2018) reports losses of between 215 and 321 kg ha^{-1} due to mechanical harvesting of excessively ripe cotton, a lower figure than that reported in this research.

Sowing period and source of water used

The cotton sowing period runs from March 20 to April 20, a period confirmed by Hernández (2009); nevertheless, due to maintenance and breakdown of canals, this year 2021, the sowing date was extended until May 2.

According to Agrotirex (2021), for the northern region, it is sown between February and April, between November and December in the Sinaloa region and around the month of July in the southern part of the country. For the state of Chihuahua, the sowing date on which the best yields are obtained is considered from April 1 to 30 and its optimal period from April 1 to 20 (Panorama Agropecuario, 2021).

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For the north of Tamaulipas, the best time for sowing has been from February 15 to March 15. The first week of March was considered the optimal time (Loera *et al*., 2015). The water sources used for cotton cultivation in La Comarca Lagunera are the Lázaro Cárdenas and Francisco Zarco dams. The opening and closing dates of the dam are historically marked by the beginning and end of cotton cultivation, so the cycle of other crops must remain within that period, otherwise they would not have surface water for irrigation.

Trend of the area sown with cotton in La Comarca Lagunera

The area allocated to cotton cultivation has decreased due to the instability of the price in the international market, the high costs of production, and the problem of the high incidence of pests, which favors the rent of land and water by small producers. In this way, farmers with good economic conditions sow larger areas with the crop.

This study identified that, of the total area sown with cotton, 70% of the area corresponds to rented land and water rights. By strata of small, medium, and large producers, the proportion of areas sown with rented rights was 47.7, 77, and 69.2% of the sown area. It can then be stated that the tendency of the crop is to be increasingly produced on rented land and water rights.

Pests and their control

Although transgenic seeds are used, which allow for a lower presence of pests, the most commonly recorded, even though controlled with different chemical products, were: boll weevil (*Anthonomus grandis* Boheman), conchuela (*Chlorochroa ligata* Say) and whitefly (*Bemisia tabaci* Gennadius), reported in 69, 49, and 25% of the farms, respectively (Table 2).

Table 2. Proportion of farms affected by the main pests at the La Comarca Lagunera level.

Pest	Proportion of farms affected			
	At the global level	Small	Medium	Large
Boll weevil (*Anthonomus grandis* Boheman)	69	100	69	65
Conchuela (*Chlorochroa ligata* Say)	49	70	50	50
Whitefly (*Bemisia tabaci* Gennadius)	25	25	28	35
Thrips (*Caliothrips phaseoli* Hood)	6	10	6	10
Armyworm (*Spodoptera exigua* Hubner)	1	0	3	0
Cotton aphid (*Aphis gossypii* Glover)	1	0	3	0

It was observed that the presence of the boll weevil and the conchuela is greater in small farms, the whitefly predominates in large farms and the armyworm and the cotton aphid only in medium-sized producers. According to SAGARPA (2012), the boll weevil is the most important pest that affects cotton production due to its ability to spread since it is easily transported within the fruits as an egg, larva, pupa, or adult.

It is important to mention that cotton areas with official recognition as areas free of regulated cotton pests bring with them great benefits, among which are: reduction in production costs, increase in the yield and quality of fiber and seed, and mobilization of cotton products and byproducts without a phytosanitary certificate of national mobilization. La Comarca Lagunera is considered within these zones (SENASICA, 2020); however, according to the findings of this study, the above is not valid.

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Diseases and their control

The presence of reported diseases is concentrated in problems of Texas root rot (*Phymatotrichopsis omnivora*) caused by the fungus *Phymatotrichum omnivorum*, which affects 32% of producers and is controlled with Pointer at a rate of 1.5 L ha^{-1}. Another reported disease is *Verticillium*, caused by the fungus *Verticillium dahliae* and favored by high humidity and temperatures of 20-25 degrees, reported by 4% of producers; for its control, they use Pointer at a rate of 1.5 L ha^{-1} or apply ammonium sulfate to the soil.

Smallpox caused by the fungus *Puccinia cacabata* occurs in 1% of the producers surveyed. These diseases also occur in the state of Chihuahua, where early drying, caused by *Rhizoctonia solani*, is also reported (Panorama Agropecuario, 2021).

Production costs

For the year of study (2021), the cost of production for a producer of 5.2 ha was $236 475.40; that is $45 476.00 ha^{-1} from the payment of planting permits to the sale of fiber, linters, and cottonseed. The benefit-cost ratio for this cycle and this producer amounted to 3.1. The important factor for these revenues was the price at which the producer sold cotton, which rose to 107.60 dollars per quintal. For Chihuahua and Baja California Sur, the benefit-cost ratio reported by the Trust Funds for Rural Development (FIRA, for its acronym in Spanish) was 1.12 and 1.19, respectively.

Yield and how to harvest seed cotton

At the level of small, medium, and large producers, the yields found by this study were 5 275, 5 923, and 6 042 kg ha^{-1}, respectively. The predominant way of harvesting is mechanical, by 98% of the producers, and completely manual with family labor, 2%. Cotton yields vary by region and climatic circumstances. In Colombia, the Ministry of Agriculture and Rural Development (2022) states that the average yield of seed cotton in the interior region was 2.3 t ha^{-1}.

Likewise, CANAINTEX (2022) reported that the cotton harvest in the state of Tamaulipas concluded with a yield result of more than 2.5 t ha^{-1} in the north of the state within the autumn-winter 2022 production period. When the cotton is harvested and in order to maintain the status of areas under sanitary control for boll weevil and pink bollworm, the destruction of regrowth by shredding by October 31 and fallowing the soil by November 30 must be complied with (CESAVECO, 2023).

Price and destination of cotton fiber

When asked about the price at which they sold cotton lint, they stated that in 2021, the price in the international market had exceeded 100 dollars per quintal, so on average, they sold at 100.25 US dollars, although the highest and lowest sales prices recorded were 120 and 90 dollars per quintal. By stratum of producers, the average prices received by small, medium, and large producers were 101.64, 97.67, and 100.25 US dollars. These prices depend on the time when the fiber is sold, as they vary from day to day.

When asked about the final destination of cotton harvested in the region, it was mentioned that it is destined for the national market (Puebla, Mexico City and Guanajuato) and export (United States of America, Turkey, Pakistan, China, Taiwan, Germany, India and Vietnam), mainly. Nevertheless, there are local purchasing companies located in La Comarca Lagunera that also buy the product.

Only 13% of producers have a sales contract with cotton marketing companies, which are sometimes the ones that finance their production process, the rest market it directly through the ginning plant. According to a study by the journal El Economista (2019), 70% of the cotton fiber produced in Mexico is destined for the national textile industry, while the rest is exported. Solleiro and Mejía (2016) point out that domestic cotton producers find marketing one of the main limitations to participate in the market since they cannot compete against the North American system based on assured quality, scheduled deliveries and credit.

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Mexican fiber consumers demand monthly deliveries, demand quality and size guarantee and purity in fiber bales; in addition, they benefit from financing. The United States of America specializes in fiber thickness and thickness. Generally, it makes a contract with the textile company in which it specifies delivery times, with this, the buyer saves on warehouse, insurance and financial costs, a situation against which Mexican producers cannot compete.

Water source and irrigation sheets

The source of water used for irrigation is the Nazas River, delivered by the network of canals; in this way, 100% of the producers use this type of water and only 2.5% use river water supplemented with groundwater. There are four irrigations for cotton production in La Comarca Lagunera, one for pre-sowing (with an estimated irrigation sheet of 30 cm) and three supplemental (with estimated sheets of 20 cm each), with an estimated total sheet of 115 cm.

For northern Tamaulipas, Loera *et al*. (2015) report that 45 to 63 cm of water are required to ensure optimal cotton production and quality, a situation that depends on the different climatic and soil conditions (evaporation and percolation) in both areas. The irrigation calendar can vary according to the type of soil and weather that prevails during the crop cycle, mainly temperature and rainfall in July and August.

Factors limiting cotton sowing

The factors that limit cotton sowing were diverse and numerous, with predominance of the following: high production costs and lack of financing for inputs, lack of land with water rights, lack of support to encourage cotton production and uncertainty in international cotton prices.

Nonetheless, when asked if they would be willing to continue growing cotton, only 9% said no, because they do not have enough land and water for it, because it is a highly risky crop in market prices, in addition to being a crop with high production costs that they cannot afford.

Conclusions

Small cotton producers are older and have a lower level of education than those classified as large producers; likewise, they have the lowest yields even though the percentage of farms registered with pests and diseases is similar. The trend of cotton crops in La Comarca Lagunera is to be planted by producers on rented land and water rights. It has ceased to be a smallholder crop, with the emergence of cotton plantations that exceed 150 ha.

It was observed that cotton cultivation is highly mechanized from sowing to harvest and uses transgenic seeds and agrochemicals for phytosanitary control. This crop has ceased to be a high generator of jobs due to its technological modernization. Cotton is a product that is quoted on the international market, specifically on the New York Stock Exchange.

The crop in the region is of high productivity, but its profitability depends largely on the international price; this year, it had an attractive price, but it can fall to levels that can bankrupt the producer. As a recommendation, this high dependence on the international price must be solved through government participation such as support in price hedging, greater credit facilitations, deposit warehouse services for the protection of fiber and immediate payment to have liquidity to pay loans and maintain the operating capacity: it is urgent to generate public policies that deal with supporting the producer.

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