Article

Characterization of maguey production in the District of Miahuatlán, Oaxaca

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Abstract

The objective of this study is to characterize the maguey production system in the District of Miahuatlan with the purpose of identifying the types of producers and the characteristics that differentiate them. Maximum variance sampling was used to select a random sample of 81 maguey producers from the District of Miahuatlán in the state of Oaxaca. The use of multivariate methods allowed the identification of three types of producers; subsistence producers (n= 36, 44.4%), producers of low productive scale (n= 31, 38.3%) and producers of medium scale (n= 14, 17.3%). The study shows that the production of maguey is done in a traditional way, although a large number of producers perform the preparation of the land with machinery (between 38.5 and 67.9%), a small number of them have technical assistance (between 25 and 39) (%) and less 15.4% perform the certification of maguey plantations. It is concluded that more than 70% of the production of maguey obtained by small producers is integrated into the production of mezcal, which requires differentiated support strategies to improve production processes by types of producers and maintain the production of mezcal traditional, that improves the income of the small family units that maintain the production of this drink.

Keywords: mezcal, problematic, traditional production, typology of producers.

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Introduction

Mezcal is a protected product with denomination of origin, which means that only certain states in the country can produce this beverage. To date, 12 Mexican states have protected territories through this designation of origin: Oaxaca, Guerrero, Michoacán, San Luis Potosí, Durango, Puebla, Tamaulipas, Zacatecas, Aguascalientes, State of Mexico and Morelos, these last three states recently included in August 2018 (DOF, 2018a, 2018b, 2018c).

At present the production of mezcal in Mexico has had an important boom, the state of Oaxaca is the one that has greater contribution to the production of mezcal at the national level, for the year 2016 it contributed 83.5% of the more than three million liters of mezcal produced in Mexico (CIATEJ-AGARED, 2017). However, the commercialization of industrial and artisanal mezcal has registered a sustained growth in the national market 110% and 137% in exports. This has led to overexploitation of the native species of the maguey mezcalero and has led to the depredation and endangerment of endemics (Martinez, 2017; CIATEJ-AGARED, 2017).

The 'mezcal region' in the state of Oaxaca includes seven districts; the Central Valleys region is made up of the districts of Tlacolula, Zimatlán, Ejutla and Ocotlán, while in the Sierra Sur there are the districts of Yautepec, Miahuatlán and Sola de Vega (Bautista and Smit, 2012). The elaboration of mezcal in Oaxaca involves eight species and seventeen protected or wild forms of maguey.

The maguey espadin (*Agave angustifolia*) is cultivated for commercial purposes in the seven districts declared by the official Mexican standard. Other species correspond to the Mexican maguey (*Agave rhodacantha*), papalome or tobala (*Agave potatorum*), bilia (*Agave seemanniana*), tepeztate (*Agave marmorata*), cirial, barrel, bicuixe, tobasiche (*Agave karwinskii*), arroqueño (*Agave americana var. americana*) and Sierra Negra maguey (*Agave americana var. oaxacensis*) (García, 2012; Espinosa *et al*., 2017).

There is a large number of studies on types of producers (Vilaboa and Díaz, 2009; Betancourt *et al*., 2015; Borja *et al*., 2016, Cuevas and Rosales-Nieto, 2018). The characterization of the types of producers allows knowing the conformation of the production systems, their components and technological management, the potential and its possible limitations, design of policies, among others. Additionally, Coronel and Ortuño (2005) point out that the adequate classification of productive systems helps to know the development dynamics of a region or the design and management of development projects.

The maguey-mezcal product system in Oaxaca identified four types of maguey producers in 2013: subsistence producers (PS), producers of maguey with low production scale (PEB), maguey producers with average productive scale (PEM) and producers of scale high productive area (PEA) with areas greater than 22 ha (Vega and Pérez, 2017). A more recent study by Martínez-Tenorio (2017) agrees with this stratification of producers and in turn identifies the surface ranges for each stratum, so the PS have up to 3 ha (represent 68.2%), PEB have between 3 and 6 ha (19.7%), PEM have from 6 to 22 ha (10.8%) and the PEA have more than 22 ha and represent 1.4%.

These studies are state-owned, so making a typology for the District of Miahuatlán can be used for the particular identification of resources and how maguey production is carried out to contribute with the design of strategies that benefit the producers of this region. and its productive activity, since the resources are different for each type of region.

Given this context, it is important to deepen the knowledge and characteristics of the producers of the mezcal zones, since this will allow the design of state and federal strategies according to the characteristics of each region and by type of producer. Likewise, the knowledge of the type of producers will allow government support to be focused on those groups that need it most and on which it is expected to obtain a greater impact. The objective of this study is to characterize the maguey production system in the District of Miahuatlán with the purpose of identifying the types of producers and the characteristics that differentiate them.

Materials and methods

Location of the study area

The Miahuatlan District is located southwest of the state of Oaxaca. The study area includes 32 municipalities belonging to the region of the Sierra Madre del Sur of the state of Oaxaca, this district is located at the geographical coordinates North latitude: 15° 40' 55'' to 16° 19' 45'' and longitude West: 95° 11' 41'' to 96° 35' 57''. The territorial surface is 3 937.97 km^2 and has an altitude of 1 600 meters above sea level. District 26 of Miahuatlan is bordered to the north by Sola de Vega, Ejutla, Ocotlan, Tlacolula and San Carlos, Yautepec and to the south by Juquila and Pochutla (Arellanes, 1996). The District of Miahuatlan is considered a potential area for the production of agave and mezcal due to its agroclimatic characteristics (Bautista and Ramírez, 2005).

Definition of sample size

The sample of maguey producers of the District of Miahuatlán was obtained from the list of producers that made the State Office of Information for the Sustainable Rural Development of Oaxaca (OEIDRUS, Oaxaca) in 2011, in this pattern it was found that the District of Miahuatlán it had 624 maguey producers. It should be noted that only in 16 of the 32 municipalities that make up the district were maguey producers identified (OEIDRUS, 2011).

The sampling design was determined from the formula for a sample of proportions of maximum variance (Infante and Zárate, 1990), which is expressed as follows:

$$n = \frac{N\ p(1-q)}{(N-1)\left(\frac{\beta}{Z_{1-\alpha}}\right)^2 + p(1-q)}$$

Where: n= is the sample size; N= is the total population of 624 maguey producers in 16 municipalities of the study region; β= is the precision in percentage equal to 10%, the confidence level was 95% (Z^2=1.96), p and q are the joint probability, where: p= 0.5 and q= (1-p) = 0.5. The

estimated sample size was n= 83 producers, representing 13% of the total population. Two surveys were eliminated because they presented atypical information. The application of the producer surveys was carried out randomly.

Instrument used and sources of information

The competitive and socioeconomic positioning of maguey has remained static during the last five years (SIAP, 2018). Therefore, the information collected; through a personalized survey of maguey producers, carried out between June and July 2014, it was considered valid.

The surveys were applied in the potential area of maguey production in the district of Miahuatlan, in the municipalities of Miahuatlan de Porfirio Díaz, Monjas, San Cristóbal Amatlán, San Francisco Logueche, San Jerónimo Coatlan, San José del Peñasco, San José Lachiguiri, San Luis Amatlán, San Pablo Coatlán, San Simón Almolongas, Santa Ana, Santa Catarina Cuixtla, Santo Tomás Tamazulapán and Sitio de Xitlapehua.

The variables included in the survey were grouped, according to the classification proposed by Knowler and Bradshaw (2007) in: general aspects where questions were included as the name of the producer, municipality and locality.

Socioeconomic aspects, in this section we inquired into issues related to peasant organization, agricultural land available. Production process, which includes the maguey production process from the preparation of the land to harvest. The survey was applied during the months of June and July 2014, applied to producers who work their plot and who lived in the locality at the time of the application of the survey.

Statistical analysis of information

The variables used to stratify the types of producers in the District of Miahuatlan integrate information related to socioeconomic aspects (age of the producer, years of being a producer of maguey, number of economic dependents and number of family employees), agricultural area (total surface of land) available, number of properties and temporary agricultural area) and practices or activities related to the production of maguey (hours dedicated to the production of maguey, distance to which sows the maguey plants, width of melgas, years for harvest, number of employed wages, number of pineapples obtained and weight of the pineapples obtained).

The answer options of the questionnaire were rated with discrete and binomial scales. Due to the complex nature of the information and after standardizing it and verifying the multivariate normality of the data, the main components technique was applied (Cuevas and Rosales-Nieto, 2018). To reduce the number of factors that differentiate the types of producers, the rotation method used was the Varimax standardization with Kaiser. Subsequently, the cluster analysis was used to graphically identify producer groups with homogeneous characteristics. The identification of the strata was carried out using the Ward method and the Euclidean squared distance (Borja *et al*., 2018).

To analyze the identified groups, descriptive statistics were used, frequencies and for the ordinal variables the Kruskal-Wallis test was applied, since when performing the normality test the quantitative variables did not comply with the normality test (Kolmogorov-Smirnov and Shapiro-Wilk test) of data ($p< 0.05$). The analysis of main components and cluster were made with the statistical package SPSS27 and Matlab V16.

Results and discussion

Main components and description of the producers interviewed. The principal components analysis (CP) identified five explanatory factors of the variables used in maguey production. CP1 refers to three variables, which collectively were designated as the social dimension of productive family units, while CP2 establishes three variables with a high weight towards the availability of resources, CP3 was designated as employment for maguey management and included two variables, family employment and working hours dedicated to the maguey, the CP4 was defined as agronomic management and finally the CP5 was related to the number of wages used in the harvest. The identified components explained 68.5% of the total of the original variation (Table 1).

Table 1. Root vectors of the first five main components in the characterization of maguey production in the District of Miahuatlán, Oaxaca.

Variable	C1	C2	C3	C4	C5
Age	0.894	0.028	0.067	-0.165	-0.042
Agave production	0.835	0.015	0.092	0.133	0-.03
Economic dependents	-0.646	0.091	0.447	-0.08	0.036
Family employment	0.016	-0.085	0.775	0.111	0.132
Land area	0.044	0.841	-0.109	0.064	0.104
Properties	0.021	0.653	0.414	-0.16	0.113
Hours of work in the maguey	0.001	-0.042	-0.589	0.032	0.356
Distance between plants	-0.064	0.73	-0.08	0.098	-0.188
Melga width	-0.173	0.012	0.213	0.8	0.283
Years to harvest	-0.276	-0.087	0.167	-0.683	0.343
Wineries for the harvest	-0.051	0.01	-0.037	0.023	0.88
Initial eigenvalue	2.1	1.7	1.3	1.2	1.1
Variance (%)	19.6	15.7	12.1	10.9	10
Accumulated variance (%)	19.6	35.4	47.5	58.4	68.5

C= component, extraction method main components. Varimax rotation method with Kaiser. The rotation has converged in 7 iterations.

The obtained Kaiser-Meyer-Olkin (KMO) statistic showed a value of 0.505, which indicates a good sample adequacy. With the Barlet sphericity test, a value of 0 was obtained, so the null hypothesis can be rejected considering the adjustment of the variables, by means of the ideal factorial analysis. The cluster analysis identified three groups or types of maguey producers (Figure 1).

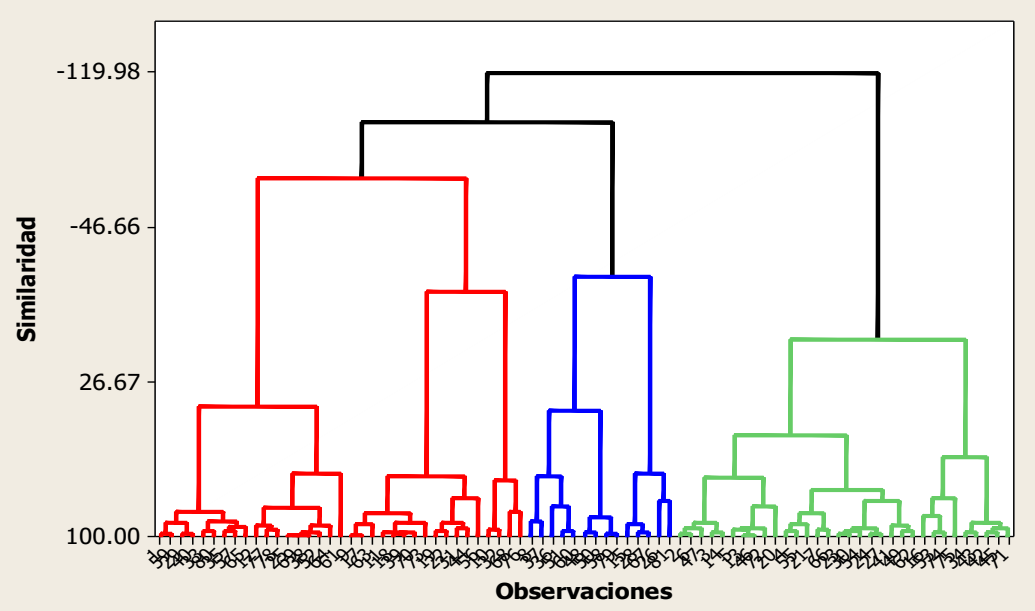

Figure 1. Dendrogram of maguey producer groups, Ward method and Euclidean square distance.

The group one of producers consists of 36 productive family units and was defined, as subsistence producers (PS), represent 44.4% of the production units analyzed, is the most representative group and among its relevant characteristics is that they have an average of age of 60.8 ±11.3 years. They have on average 3 ±2 economic dependents and an average temporal area of 2.4 ±1.9 ha dedicated to the production of maguey. It is the majority group and has an advanced age and a low productive agricultural area.

Cluster two groups 31 productive family units and was defined as producers of low productive scale (PBEP), they represent 38.3%, it is a group very similar to the PS stratum but it stands out for having a younger age (47.4 ±12.4 years) and approximately one hectare more for production, have two economic dependents more than cluster 1. Cluster three, is composed of 14 productive family units and was defined as medium-scale producers (PEM), represent 17.3%, have an average age of 51.1 ±20.3, they have 4 ±2 family dependents and 6.2 ±3.9 ha of seasonal production.

The three types of producers identified are in accordance with the typology elaborated by the mezcal product system of the state of Oaxaca and with that reported by Martínez-Tenorio (2017). However, in the present investigation no producers of high productive scale were identified, which indicates that the production in the District of Miahuatlán is carried out by small and medium producers of mezcal.

Social dimension of productive family units

The PS are of advanced age (62 years of median value, p= 0.001) and they are those with more years of experience in the production of maguey, secondly, they are the PEMs and thirdly the PBEPs which have less years of producing maguey and they are the youngest producers (average

age of 47 years). In general, the variable years of production evidences the traditional part of the production of maguey for the elaboration of mezcal (Table 2), since when comparing the average 25.5 years that producers of the district of Miahuatlán have to produce, with those of other producers from other states, such as those from Zacatecas at age 15 (García and Macías, 2010), highlight the experience and attachment of this agricultural activity in the study region. Therefore, we can observe an ingrained identity that is transmitted; through, of the generations (Bautista and Terán, 2008).

The level of education of the PEM is higher than the PS and PBEP, since 23.1% of this group of producers have higher education at the secondary level, compared to 12.9% of the PBEP and only 5.7% of the PS. The results obtained contrast with what Bautista and Ramírez (2008) point out, regarding the average schooling of maguey producers, which was five years at primary level and an average age of 52 years.

Table 2. Socioeconomic aspects of maguey family units, 2014.

Variable	PS	PBEP	PEM	p^*
Age	60.7 ±11.3 (62)a	47.4 ±12.4 (46)b	51.1 ±20.3 (45)b	0.001
Years of producing maguey	33.3 ±15.4 (35)a	18.5 ±7.7 (17)b	24.3 ±18.6 (16)b	0.001
Economic dependents	3 ±2 (3)a	5±2 (4)b	4 ±2 (4)b	0.024
Scholarship (%)				
Without study	25.7	6.5	7.7	
Primary school	54.3	61.3	53.8	
High school	5.7	12.9	23.1	
Preparatory	0	3.2	7.7	
Bachelor's degree	0	3.2	3.2	

*= value of the Kruskal Wallis test ($p< 0.05$), (median).

The age and schooling of producers are factors that directly influence the way of cultivating and the availability of adopting new technologies (Borja-Bravo *et al*., 2016). Education and age should be considered for the definition of differentiated strategies, since there are young producers (the PBEP stratum) with a good level of education, which may be more receptive to new strategies of technological change. A higher level of education allows access to updated information and innovation in technological aspects, a situation that coincides with that found by Chilonda and Van Huylenbroeck (2001).

Availability of resources

The type of property that the producers have is mostly private property. The group of PEM is the one with the largest area of rainforest (8; $p= 0$), between 25.7 and 39.3% of the producers have technical assistance and more than 55.6% have maguey nurseries (Table 3).

Financing in the agricultural sector is a fundamental part of the production process, since it provides the necessary cash flow for the acquisition of working capital (Salinas *et al*., 2017). According to Bautista and Ramírez (2008), in a study carried out in Matatlán, more than half of the producers finance the production of maguey through remittances, a smaller proportion with own resources and scarcely 14% receive governmental support. The results obtained agree with this research, since only two strata indicated financing for production, PS (11.4%) and PBEP (10%) (Table 3).

Table 3. Resources available for the production of maguey, 2014.

Variable	PS	PBEP	PEM	p^*
Surface of temporary (ha)	2.4 ±1.8 (2)a	3.3 ±2.3 (3)a	6.2 ±3.9 (8)b	0
Number of properties	2.2 ±1.2 (2)a	2.8 ±1.3 (2)a	3.3 ±1.7 (3)a	0.119
Has technical assistance (%)	25.7	39.3	28.6	
Has nursery (%)	55.6	96.8	64.3	
Has financing (%)	11.4	10	0	

*= value of the Kruskal Wallis test ($p< 0.05$), (median).

Of the total of producers interviewed, only 15 reported participating in a producer organization: seven PS, five PBEP and three PEM. The type of support they receive for being in an organization focuses on technical assistance, financing and commercialization of the mezcal produced.

Employment in family units

The number of family employees and the months of family employment did not show a significant difference ($p> 0.05$); that is, the number and months of family work in the three strata is similar. The majority of maguey producers do not hire labor they use the work of the family (Bautista *et al*., 2015). Of the total productive units, only 9.7% (PBEP), 22.2% (PS) and 28.6% (PEM) are dedicated exclusively to the production of maguey for sale as raw material and more than 70% of the three strata are intended, for the production of maguey for mezcal (Table 4).

Table 4. Employment level and purpose of production in family units, 2014.

Variable	PS	PBEP	PEM	p^*
Family employees	2 ±2 (2)a	2 ±1 (2)a	1 ±1 (1)a	0.672
Months family employment	1.7 ±1.6 (2)a	3.4 ±3.6 (3)a	2.8 ±2.3 (3)a	0.212
Destination of pineapples (%)				
Production of maguey	22.2	9.7	28.6	
Production of mezcal	77.8	90.3	71.4	

*= value of the Kruskal Wallis test ($p< 0.05$), (median).

In contrast, in a study conducted by García-Salazar and Macías-Rodríguez (2010) in a community in Zacatecas, only 27% of the producers are engaged in producing mezcal; that is, they are linked to the production chain. According to a study conducted by Curiel-Avilés *et al*. (2016) within the mezcal value chain, maguey producers only obtain 6% of the added value.

Agronomic management of the maguey productive system

The registration of maguey plantations is an activity that is carried out before the Mexican Council of the mezcal, in the study it was identified that less than 15.4% of the producers carry out this activity (6.1%, 15.4% and 10% of PS, PBEP and PEM, respectively). According to Bautista and Terán (2008), producers cannot access the certification processes due to lack of economic resources, which limits their negotiation power against the industrial ones at the time of sale. The planting of maguey is carried out in association with other crops (usually maize and beans), in this sense, practically the total of the producers is associated (Table 5).

Table 5. Agronomic elements of maguey production, 2014.

Variable	PS	PBEP	PEM
Production system (%)			
Monoculture	5.7	12.9	7.1
In association	94.3	87.1	92.9
Variety planted (%)			
Sprat	53.3	50	66.7
Mix of varieties	46.7	50	33.3
Land preparation (%)			
Machining	48	67.9	38.5
Manual (yunta)	48	32.1	53.8
Weed control (%)			
Manual	80	70.4	100
Chemical control	16	25.9	0
Both	4	3.7	0

In this regard, Sánchez (2005) determined that the practice of planting maguey mezcalero associated with annual crops is carried out in this region with the aim of improving soil conditions, especially in the collection and retention of moisture, reduction of pests and diseases and improve the harvest of annual crops.

The variety of plant that is most used in the production of mezcal is the espadin agave (more than 50% of the producers use this variety). The use of sprat can possibly be explained by the fact that this species has a short cycle it has larger pineapples, so it is of higher yield, it provides the greatest volume of raw material for the elaboration of mezcal and it is easy for the reproduction of plant (Mariles-Flores *et al*., 2016). However, they use other species such as mother cuixe, tobala, tepextate, bicuixe, cenizo and arruqueño and mixtures of some of these types of maguey, almost always with sprat.

More than 38.5% of the producers use machinery to prepare the land, but it is the PBEPs who use the machinery the most. This result contrasts with that found by Bautista and Ramírez (2008), who point out that most of the maguey production units do not have agricultural machinery particularly tractor, due to the lack of economic resources or the adverse conditions of the land. Weed control is mostly carried out manually this can be explained given that maguey plantations are established in soils with a minimum arable layer, which limits the growth of other types of plants (Bautista and Smit, 2012).

Harvest

The producers of low productive scale (PBEP) are those that have a higher average amount of wages for the harvest (5; $p= 0$). Regarding the number of pineapples produced and the average weight, there was no significant difference ($p> 0.05$) in the three producer strata, which may indicate a similar technological management. An investigation carried out in four localities of the state of Oaxaca, identified that the espadin plants (*Agave angustifolia* Haw.) Harvested in the communities of San Antonino Castillo Velasco, Soledad Salinas and Xitlapehua, had a great variation in the size of their pineapples, with fluctuations in values of fresh weight found from 31 to 133 kg and with an average weight of 80.87 kg (Cruz *et al*., 2013).

This characteristic can affect the planting of sprat by producers. Espinosa *et al*. (2017) they point out that the small producers of mezcal have endured as economic units because of the family sense that characterizes them since many times the members of the family do not receive an income, because they are not considered as employees, which causes the costs regarding labor in the production of mezcal are low or non-existent (Table 6).

Table 6. Pineapple harvest in the Miahuatlán maguey production system 2014.

Variable	PS	PBEP	PEM	p^*
Wineries for the harvest	2.5 ±1.15 (2)a	4.3 ±1.2 (5)b	2.5 ±0.8 (2)a	0
Pineapples produced (#)	165.6 ±146.6 (150)a	226.5 ±159.9 (200)a	259.2 ±171.5 (200)a	0.287
Average weight of the pineapple (kg)	61.1 ±23.1 (50)a	64.7 ±19.7 (60)a	58.7 ±21.1 (65)a	0.631

*= value of the Kruskal Wallis test ($p< 0.05$), (median).

The production of maguey is integrated in the three groups, since 69.4 and 76.7% of the producers of the three strata use the pineapple for the production of mezcal. These results confirm that mezcal production is carried out by small producers who have a traditional knowledge that they maintain and is reflected in the mezcal produced by each of these small family units.

Conclusions

The study identified three types of producers, subsistence producers who have less than 2.4 hectares, producers of low productive scale who have an agricultural surface range of 3.3 to 5.6 ha and medium scale producers that have more than six hectares. The largest amount of resources and

production of pineapples is in the stratum of producers of medium scale, they are young producers of 51 years, in contrast, subsistence producers are over 60 years old. Between 38.5 and 67.9% of the producers carry out the preparation of the land with machinery, from 25 to 39% have technical assistance service and less 15.4% carry out the certification of the maguey plantations.

The study shows that the producers of the subsistence stratum are the most representative, they are older and have less resources for production. In contrast, the stratum of producers of low productive scale has a good level of schooling, they are younger and therefore they can be more receptive to new strategies of technological change.

More than 70% of the maguey production obtained by the small producers of the District of Miahuatlan, is integrated into the mezcal production and follows a traditional process, which demands differentiated support strategies to improve the production processes and maintain the elaboration of mezcal in a traditional way, to improve the income of the small family units that maintain the production of this drink.

As new lines of research, it is recommended to design differentiated strategies to support primary production and industrialization in order to promote better yields in pineapple production and greater well-being of mezcal producers. It is recommended the identification of technological packages appropriate to each stratum of producer, since the production is carried out in a traditional way which can affect so that at present the same production of pineapples is obtained in the three identified groups. The consideration of available resources and the definition of technology appropriate to the type of producer can be elements that make more efficient the production of maguey and mezcal in the study region.

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