Essay

Programmatic interventions and bioeconomy: rethink the viability of Maguey

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Abstract

The paper bases the possible profitability and sustainability of the maguey plant from the biomass criterion and business paths, all in the context of the dissimilar logics of intervention, transfer and science that have been applied around the plant. The relevant literature review and the guide for the identification and analysis of the business possibilities of the bioeconomy are the main inputs necessary to achieve this end. Thus, it is possible to affirm that, although the maguey for mead/pulque is perhaps the most studied plant (linked to the indigenous past) since colonial times, today it gravitates in its last programmatic phase of incidence, survival, and preservation of cultural knowledge. Moreover, the paper shows that apart from pulque, it is feasible that the future of maguey embraces its multifunctionality and its multifaceted character, a synergy that will undoubtedly grant business viability to the average producer, especially in minimizing the maturity time factor versus disinterest in growing the plant.

Keywords: biomass, maguey, programmatic interventions.

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For the integrated taxonomic information system (SIIT, for its acronym in Spanish) of the National Commission for the Knowledge and Use of Biodiversity (CONABIO, 2013), the maguey plant (of indigenous origin) is part of the family and genus of the agaves, its distribution covers from the south of the United States of America to Bolivia, Paraguay, Colombia and Venezuela. Mexico concentrates about 150 species of the 200 registered worldwide, plus 36 species that belong to infraspecific categories, in sum, they constitute a total of 186 taxa (García, 2007). Even though 30 species are recognized on the maguey area of Hidalgo, the institutional accounting, the scientific contribution and the reality of the producer quantify the loss of notable varieties, taxonomic and phylogenetic groups (García and Galván, 1995).

Especially at the end of the twentieth century, 1 700 ha of maguey for mead/pulque managed to reach the appropriate age (between 8 and 12 years, in six stages, passing through: medio cubo, al hilo, capón, añejo, raspa, escurrido), after two decades, the quantity registers negative variation of up to 300; that is, on average 30 ha of maguey area disappear each year (SIAP, 2000-2010). Such a scenario contrasts too much with the historical/economic relevance of the maguey for mead/pulque, once considered the main axis of accumulation in the agrarian economy of Hidalgo. Since, in comparison with the most critical stage of the import substitution logic (1940-1980), 17 times more that reached the fruitful period and about 147 in the Porfirian period (1876-1911) were quantified, the golden age of the so-called fine pulque (Loyola, 1956) (DGE, 1937-1975).

The loss of maguey implies a deficit to a numberless of documented descriptors around the plant, to mention a few: ancestral knowledge, food staggered with certain legumes and vegetables, construction of houses, livelihood, rooted customs and knowledge, cultural practices and agroecological value, use of clothing, bioeconomy and industrial prototypes, latifundia and pulque estates, subjects and agrarian struggle, economic monopoly and political power, reforestation and erosion, gastronomy, food and medicines (Ramírez, 2000).

Nowadays the information available on the national agrarian public policy recognizes, within the state of Hidalgo, a certain diversification of the use of the maguey plant: two municipalities with planting of maguey for leaves (947 ha), one with maguey for mixiote (23 ha) and 43 with maguey for mead/pulque (5 100 ha), but in almost all cases, the trend of functionality of the plant is limited, 29 out of 100 planted ha end the age propitious to their exploitation (SIAP, 2018).

Due to this reality, the paper tries to show the results of a certain academic link with producers and decision makers that allowed to base the possible profitability and sustainability of maguey from the bioeconomy approach (Schmid *et al*., 2012), all framed under the context of the dissimilar programmatic logics that the agri-food chain has gone through (interventions, transfer and applied science). The bioeconomy is assumed as the knowledge-intensive production and use of resources, processes and biological principles for the sustainable provision of goods and services in all sectors of the economy; the starting point is the sustainable production of plant, animal and microbial biomass, taking advantage of photosynthesis to produce, in addition to food, energy and a wide range of environmentally friendly biomaterials (IICA, 2019).

With such an approach, it is sought to demonstrate the greatest possible value addition of the maguey resource through the efficient use of both primary and residual biomass. The academic link with producers and decision makers is part of the analysis and evaluation 10 years after the

promulgation of the current Law for the Sustainable Management of Maguey of the State of Hidalgo, an effort made by the Commission for Agricultural Development and Hydraulic Resources of the LXIV of the Free and Sovereign Congress of the State of Hidalgo and members of the Maguey Cactus pear Scientific Network. Both the biomass criterion and business paths were the guiding axes that focused on discussing and substantiating the reality of the current regulations and the programmatic impact of public policies, moreover, the creation of solutions that allow influencing the protection, conservation, promotion and use of the plant.

In the first section, from the relevant bibliographic review, the dissimilar programmatic logics of intervention in the maguey were outlined. This approach characterized most of them by certain institutional frameworks, tortuous actions, regressive puzzles and sporadic efforts. From the historical and current evidence, it is possible to affirm that: although the maguey for mead/pulque is perhaps the most studied plant (linked to the indigenous, rural, hardworking, impoverished and marginal past) since colonial times, today it gravitates in its last programmatic phase of incidence, survival and preservation of cultural knowledge. Paradoxically, this is characterized by a set of actions (far from a real institutional policy) that seek to introduce to the logic of the plant certain criteria of recovery, reuse and recreation.

In this section, the visual representation of the territory is decisive, therefore, through the Geographic Information Systems (GIS), the historical and spatial trend of the plant is exemplified. In the GIS, the centroid represents the maguey-producing locality, official data from the database called main data by locality ITER were used, which include the coordinates that allow to define only the centroids of the polygons of the existing localities. Once these data were obtained, these coordinates were converted to the UTM system, datum WGS 84, since they are originally in geographical format in degrees, minutes and seconds.

Once the coordinates were converted to this system, they were represented using ArcGis 10 software and converted into a vector file of points. Through the geographical key of locality as a key field, the data of maguey-producing hectares of almost 100 years were joined, to represent the assigned areas proportionally, it was chosen to represent them equidistantly in all directions, in such a way that the assigned area is represented in the form of circles. To this end, initially, the area was converted from hectares to square meters and the following formula was applied, in order to obtain the radius of the areas of influence, $r=\sqrt{\frac{A}{\pi}}$. Where: *r* is the radius that is sought to represent, A is the area in square meters and π was rounded to 3.141597.

In the second section, based on the scientific evidence and validation in the maguey area of Hidalgo (semi-structured interviews with producers in the municipality of Cardonal), the methodological logic that allowed the obtaining of biomass from a maguey plant is based. This was characterized by being castrated, medium-sized variety, propitious age 8-10 years, 145 days of exploitation, higher quality of mead, 14-15 degrees Brix, of sufficient diversity with respect to the other existing varieties (Alfaro *et al*., 2017). The guide for the identification and analysis of the business possibilities of the bioeconomy (IICA, 2019), validated by the Bioeconomy and Productive Development Program of the Inter-American Institute for Cooperation on Agriculture, was the main input that allowed quantifying such a methodological effort.

The results were: 601.82 kg leaf, 370.1 kg mead and 28.1 kg scraped fiber, which, weighting the criteria defined for agri-food chains (Trigo *et al*., 2013), demonstrate the possible viability of business paths via income/sales, moreover, the current multifunctional and multifaceted vision that can still dominate for the maguey plant is reiterated.

Logics of intervention in the production of maguey

First logic of intervention. Especially for the historic 100 estates and ranches engaged in the production of maguey for mead/pulque, which came to represent 250 thousand hectares during the Porfirian period (Ramírez, 2000), coupled with the proximity and rail connectivity with the traditional industrial nodes of the country (today called Mexico City and State of Mexico), the productive attention is focused on the so-called fine pulque produced in the Llanos of Apan, this is a fermented, white, viscous, acidic drink, pH 3.5 to 4.3 and slightly alcoholic: 4-7 (%) of ethanol (Ramírez, 2018). On average, between 1896 and 1916, each inhabitant of the Mexican capital drank 0.9 liters of pulque daily, most of the production coming from the Llanos de Apan, this region, by the literature, coincides in delimiting it to the fractions belonging to the State of Mexico, Mexico City, Tlaxcala, Puebla and Hidalgo, which circulated around the municipality of Apan (Leal and Huacuja, 1982).

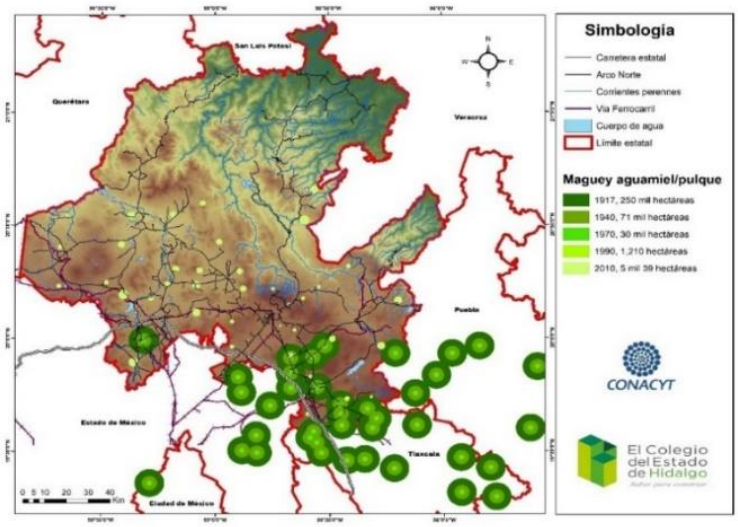
Such productive relevance pushed certain efforts that tried to intervene, transfer and apply science to the maguey, but they were truncated by the causes/consequences of the restructuring suffered by the agricultural area from the allocation and execution of *ejido* land from 1917 (year in which the first exercise occurs at the state level) and until 1940 (when the agricultural export logic in Mexico ended) (Roldán, 2018).

The revolutionary process banished the majority of the pulque aristocracy, economic/political power linked to the Porfirian period, directly responsible for encouraging some diversification of the plant, to mention some documented achievements: maguey syrup (concentrated mead), agavan (concentrated nectar), industrial alcohol (pharmaceutical), vinegar (fermentation of mead), gum (industrial glue), ixtle (quite fine, white and resistant fiber) and fodder for cattle (chopped leaves and the remains of the plant) (Ramírez, 2018). Also note the attempt at that time to minimize the unhygienic in the production of pulque, among other innovations: mud covers instead of stones on the castrated magueys; paraffin-waxed wooden barrels that facilitate washing inside; mead extraction pumps that would replace the use of acocote (Olea, 2006).

The technology transfer actions, some patented, were too much endorsed/carried out by private companies located in what is now called Mexico City, Hidalgo and the State of Mexico; the most critical example is the Compañía Expendedora de Pulques, S.C.L. and the Compañía Realizadora de Pulques, SA (Macedo, 1950). In short, almost 23 years after the beginning of the allocation of ejidos (1917), the Hidalgo's production of maguey for mead/pulque (with a limited quantity and few technology-transfer processes) still ranked first at the national level (71 thousand hectares), 25% larger than that of its closest competitor (Tlaxcala) and 1.5 times higher than that of the State of Mexico, state that ranked third at the national level in those years (Olvera *et al*., 2010) (Figure 1).

Second logic of intervention. This is framed in the last two decades of the substitutionary logic (1960-1980), having as antecedent the accelerating legends or black campaigns around the maguey for mead/pulque: it was said that it was fermented with animal and human excrement. The responses were, from public policy, certain institutional efforts that tried to obtain the sanitization, production and technological transfer to the plant, especially led by the Maguey National Commission (1954) and the Maguey Foundation (1960-1977), later called Promoter of Maguey and Cactus pear (1980-1982), efforts directed mostly by natives of the Llanos de Apan (Herrera, 1980).

The aim was to rescue, exploit and reformulate the knowledge, contributions, transfer and added value made during the Porfirian period, now mostly endorsed among other institutions by the National Chamber of the Pulque Industry (CNIP, for its acronym in Spanish), Secretariat of Health and Assistance, Secretariat of Industry, Commerce and Labor, School of Architecture and Institute of Biology (National Autonomous University of Mexico), Latin American Indigenous Institute, Secretariat of Health and Assistance, Mexican Academy of Gastronomy and Bromatology, Mexican Society of Agriculture. Such achievements went from tools of rural change (1950) to definitions of technological packages (1960-1970), directed by deficient brochures and divulgation texts that did not permeate the average producer, often revolved around the patrimonial and moral discourse; that is, precarious availability of technological capabilities associated with programmatic continuity (Herrera, 1980). In Hidalgo, despite the fact that the area planted with maguey for mead/pulque amounted to 30 thousand hectares on average (65% of the country's maguey area) and 60 thousand peasant families depended economically on the plant, the pulque industry of Hidalgo decreased by about 70% in real terms (Roldán, 2015) (Figure 1).



Map 1. Location of maguey for mead/pulque (Ramírez, 2000; Olvera *et al*., 2010; Roldán, 2015; DGE, 1937, 1975; SIAP, 2012-2017).

Third logic of intervention. This is framed by the crises of public policies and strategic projects around the open economy (1982-2000). That is, under criteria of rationing/channeling economic resources, the Promoter of Maguey and Cactus pear, in addition to the Indigenous Foundation and

the Trust for the Development of Palm and Fund of Ejidos, merges with the National Commission of Arid Zones (CONAZA, for its acronym in Spanish), and this was implemented from 1970 to provide attention to a certain important set of the population that lives in the arid and semi-arid areas of the country (Valadez, 2014).

Thus, insipid actions were attempted to transfer by-products of the plant or generation of added value, without any success in their majority. The organizations and groups of maguey producers could not organize and influence due to the network and imposition of bureaucratic foundations and unions that did not share the interest of strengthening the production of the plant, the result, the disincorporation of the National Chamber of the Pulque Industry (CINP, for its acronym in Spanish) of the National Chamber of the Transformation Industry (CANACINTRA, for its acronym in Spanish), privatization of the receiving plants and the railway service associated with the transit of the maguey for mead/pulque, for example the Pantaco Station (Valadez, 2014).

In response to this scenario, the public administration in turn spread, without any success in its operation, the Regional Plan for the Development of the Maguey Zone (PRDZM, for its acronym in Spanish), it was argued, among other realities, that the lag in agricultural production and the inflationary process contributed to a greater polarization of wealth and exacerbation of the needs of economically weak strata. With no documented impact of the PRDZM, statistical information indicated that, on average at the end of the last decade of the twentieth century, 14 out of every 100 hectares planted with maguey for mead/pulque reached the appropriate age (8-10 years) (SIAP, 1990-2000) (Figure 1).

Fourth logic of intervention. This stage begins from the so-called political alternation of Mexico (2000), since, far from the real institutional programming, a series of normative, institutional, empirical and scientific actions are gradually combined, which paradoxically affect the prompt recovery, reuse and recreation to the productive logic of the maguey for mead/pulque. Namely, the three main ones with the highest impact are listed.

First impact, with the publication of the Law of Sustainable Agricultural Development for the State of Hidalgo (2006), the Comprehensive Rural Training and Technical Assistance is founded, perhaps called rural extension work (POGEH, 2006). Plantations or traditional foods of the agricultural economy of Hidalgo (for example, the maguey plant) were prioritized from their early years, most of them implemented through the system-product (SP) and Committees of the Mexican Council for Sustainable Rural Development (CCMDRS, for its acronym in Spanish) (Echeverri, 2016).

Second impact, with the promulgation of the Law for the Sustainable Management of Maguey published on December 31, 2011, by the Official State Newspaper (POGEH, 2011) and the respective rules published on October 8, 2012 (POGEH, 2012), an attempt is made to influence the propagation of maguey and pollinators of the plant not intended for the exploitation of mead/pulque, from asexual reproduction (until 2016) to *in vitro* propagation (current). Asexual reproduction was introduced through communal nurseries, installed in spaces with almost no historical maguey significance, under the justification that an adult plant can generate up to 50 suckers (CIATEJ, 2017).

While in *in vitro* propagation, controlled germination allows obtaining desirable characteristics: precocity, rapid growth, leaves without thorns (on edges), more and better fiber (long), higher weight yield, enough resistance to drought, humidity, diseases or alkalinity, vast sugar content, to mention a few. Such propagation is implemented (without connection with the actions of reproduction by suckers) with the construction of regional nurseries in the main emblematic areas of maguey, consulting services are provided by companies that produce plants on a large scale (Vázquez *et al*., 2011).

Third and final impact, with the publication of the standard 199-SCFI-2017, an attempt is made to regulate and formalize the consumption of pulque (fermented alcoholic beverage) in two categories: natural pulque and cured pulque, especially to intensify pulque production on a medium scale, from the artisanal to the industrial way (Lappe *et al*., 2008). Today there are several companies that produce processed pulque with characteristics different from the traditional one, where the main challenge of most artisanal and industrial efforts is adaptability to the dissimilar preferences of the consumer and exploit the various uses of pulque/mead (Aguilar *et al*., 2014; López *et al*., 2017).

Biomass and business viability of maguey

Throughout its life, the plant can be used for its by-products and diversifications, both in whole state (untouched), capado (castrated) and saltado (another scape appears after the first) (Vázquez *et al*., 2016). In the municipality of Cardonal, the activities carried out (producers interviewed and explanation collected in the field) allowed determining the biomass of castrated maguey. This area is located northwest of the state of Hidalgo, is distinguished by its historical marginalization, semi-desert climate with extreme temperatures, limited precipitation and xerophilous vegetation: mesquite, huisache, garambullo, cactus pear, biznaga, pitaya, cassava, among others, which hinders agricultural production (Moreno *et al*., 2006). However, Cardonal (called *seí* in Otomi and *octli* in Nahuatl) is the entity with the highest representativeness of maguey for mead/pulque in the state, contributes about 21% of the value of production with a yield of 108 liters per hectare, 37 out of every 100 planted successfully reach the appropriate age (145 days, medium-sized variety) (SIAP, 2018).

Today 80 ha planted with maguey for leaves are recognized, they receive on average 5 thousand pesos for the sale of 11 kg per capita of hectare (SIAP, 2018). Despite the proximity of Cardonal to the Irrigation District 03 Tula, the maguey plant suffered a different fate than corn and alfalfa, its irrigation was exclusive, in addition to the terrible quality of water, to reach its appropriate age; however, in some localities, the cultivation of maguey is in the process of revaluation, mostly due to the ecotourism boom and other activities typical of adults, also partly due to the apathy of the young population (Vázquez, 2018).

It is possible to systematize in six points the obtaining of the biomass of maguey (castrated), namely: 1) on average, 145 effective days of the productive cycle of a maguey plant (medium-sized variety, 8-10 years), from the extraction/castration of the meyolote until eliminate the plant of the *melga* (the rows of this plant). Between spring and autumn, the frequent period in which such operations are carried out; 2) on day 1 of scraping of the plant, an average of 1.5 kg is obtained from the *meyolote*, derived from the respective castration; 3) for day 2, it is advisable to let the maguey plant rest, no residues that represent biomass are obtained; 4) on day 3, the scraping

technique is performed, an action that per day allows obtaining about 200 g of scraped fiber (d) and 0.4 L of mead (c); 5) day 4 to 58, continuity in the process of cultural management of the plant, 200 g of scraped fiber (*mexal*) and on average 5 L of mead (Ortiz *et al*., 2008); and 6) day 59 to 135, the same 200 g of scraped fiber (d) are obtained, however, the yield of the production of mead (c) decreases, average plus minus 0.5 liters (Muñiz *et al*., 2013) (Figure 2).

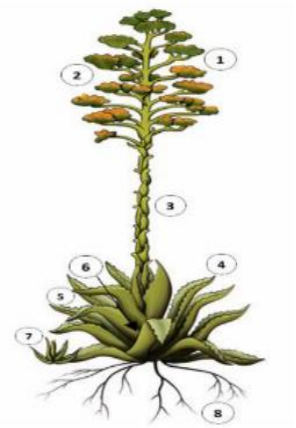


Figure 2. Morphology of the maguey plant. 1) flower; 2) seed; 3) scape; 4) thorn; 5) leaf or *penca*; 6) stem or *piña*; 7) suckers; and 8) root (MNCP, 1988).

In sum, of the total production cycle of mead (c) of a maguey plant (medium-sized variety, 8 to 10 years), which is equivalent on average to 145 days (4.5 months), 286.89 L are obtained, crystalline yellowish color, sweet flavor and herbaceous smell; consisting of water, sugars, proteins, gums, salts and minerals (Lappe *et al*., 2008). From the criterion of density liters/kilograms, 370.1 kg of mead(c) are quantified: 370.1 kg per 1.29 g liters of mead. The partial sum of scraped fiber (d) during the production cycle of mead (c) registers a value of 28.1 kg plant^{-1}.

Thus, the mathematical statement of maguey (castrated) biomass is as follows: a= b+c+d. Where: a=1 000 kg of average weight of the maguey plant (medium-sized variety, 8-10 years); b= leaf, the unknown to be defined (all that vegetative material removed in the appropriate age); c= mead, 370.1 kg and d= scraped fiber, 28.1 kg. Substitution and clearance: 1 000= b+370.1+28.1; 1000=b+398.2; b+398.2=1000; b=1000-398.2; b=601.82 kg. Assuming that the rest of the factors remain constant, it is indicated that, on average, the effective biomass for a plant of castrated maguey (medium-sized variety, 8-10 years, with a productive cycle of 145 days) is 601.82 kg of leaf (b) (includes up to the *mezontete*), 370.1 kg of mead (c); and 28.1 kg of scraped fiber (d) (includes *piña*, *meyolote* and *metzal*) (Figure 1).

Although various uses around the maguey have been documented over time: 71 (MNCP, 1988), 32 (Flores *et al*., 2009), 78 (Vela, 2014), for the purposes of this paper, from the criterion of maguey (castrated) biomass obtained, the possible business criteria, already validated by some scientific evidence, are presented. That is, of the 601.82 kg of leaf, one can obtain: *ixtle* bags (1 805 pieces) and fresh leaves (in a day to feed on average 20 sheep), both produced with artisanal methods (Table 1). For the first, the estimate of average income per production cycle of the plant amounts to about $450 000.00 pesos, while in the second, the income/savings weights about $6 750.00 pesos (Table 1).

Table 1. Maguey biomass and business viability.

Biomass criterion	Yield	Theoretical justification	Production method	Production estimation	Average income	Current market case
Leaf= 601.82 kg	1 kg of leaf to produce 3 pieces of bags	(Nieves *et al*., 2007).	Artisanal	1 805 pieces of bags	$250.00 pesos per piece; total $450 000.00	Hidarte
	3 kg leaf (fresh-green) for fattening 1 sheep (20 kg)	(INIFAP, 2011).	Artisanal	In one day, 200 sheep fed with leaf (fresh green)	Savings $6 750.00 pesos	Regional cattle market
Scraped fiber= 28.1 kg	2 100 kg of scraped fiber to produce 1 piece of maguey paper (25 cm high by 70 long, 0.21 ml thickness)	(Gentry, 1982); (Garcia, 2002).	Artisanal	13 pieces of maguey paper	$350.00 pesos piece; total $3 145.00	Beyond Gourmet
Mead= 370 kg	10.36 kg of mead to produce 1.5 kg of maguey syrup	(CIP, 2005).	Artisanal	45.19 kg of maguey syrup for 180 bottles (0.25 g).	$100.00 pesos per piece; total $18 076.00 pesos.	Naturel (0.25 kg)
	100 g of mead to produce 4.70 g of inulin	(Flores, 2008)	Industrial, spray drying	17.39 kg of inulin for 35 pieces (0.5 kg).	$214.00 pesos per piece; total $7 443.00	Enature (0.5 kg)
	0.992 kg of pulque to produce 0.039 kg of ethanol.	(De León *et al*., 2008).	Semi-industrial, Distillation	27.85 kg ethyl alcohol (70-80% purity) for 70 bottles (0.50 L).	$30.00 pesos per piece; total $2 100.00	Protec (70 purity, half a liter).
	0.1036 kg of mead to produce 0.508 kg of maguey gum	(Lappe *et al*., 2008).	Semi-industrial, evaporation and drying	1 814.28 kg of maguey gum for 8 bottles (0.250 g).	$140.00 pesos per piece; total $1 015.00	Mi Granero (0.250 g).
	5.18 kg of mead per 9.92 kg of pulque	(Aguilar *et al*., 2014).	Industrial, double pasteurization and canning	714 28 L of pulque for 2 138 of canned pulque (0.334 L).	$20.00 pesos per piece; total $42 771.00	Pulque Néctar del Razo (0.334 L)

For the 380 kg of mead obtained, the by-products and diversifications that can be obtained from artisanal to industrial methods account for average incomes of, in order of intensity, $42 771.00 pesos (canned pulque); $18 076.00 pesos (maguey syrup); $7 443.00 pesos (inulin); $2 100.00

pesos (ethyl alcohol) and $1 015.00 pesos (maguey gum) (Table 1). Finally, for the 28.1 kg of scraped fiber, with 13 pieces of maguey paper, about $3 145.00 pesos are collected (artisanal exploitation) on average (Table 1).

It is important to indicate before the end of the section that, although the soil and climatic conditions influence the growth of the plant, the tasks/strategies of the producers and the responses of the agricultural public policy are also important, namely, three conditions to be weighed are presented. First condition: the staggered planting(validated), after four years of growth of the maguey plant via nursery (50 to 70 cm), it is transplanted to a high-density system, where its growth is planned for four more years, based on a gradual and scaled productive reconversion, efficient and intensive use of space.

In a row, the magueys from the nursery, with four years of growth, are transplanted, with six meters of separation between each row and two meters between each plant. After two years, another row of magueys from the nursery is sown again, now with a separation of two meters between one of the rows of the plants with six years of growth, four years in the nursery and two in the field, and four meters from the other row. After four years, a row of magueys from the nursery is sown again, with a separation between each row of two meters. Thus, having three rows of staggered growth: eight years, six years and four years (González, 2017).

Second condition: historical cultural practices (pruning, weeding, fertilization, cuticular damage, at least twice a year) and pest/disease management (the so-called weevil, the main pest that affects the plant almost all year round, causes tissue degradation and plant death, from 30 to 93%), which are combined with the production of artisanal biopreparations, to mention a few: biostimulants, rooting agents, biofungicides, bioinsecticides, biorepellents, biofertilizers (Solís *et al*., 2001; Vázquez *et al*., 2016).

And finally, the third condition: derived from the wide distribution in limiting environments (shallow, infertile and dry soils), the analysis of the genetic variation of maguey that allows achieving the conservation and the implementation of genetic improvement programs is decisive. Estimators of the extent of available genetic variation contribute to germplasm monitoring and allow predicting potential genetic gains (Moreno and Cubero, 1993).

Conclusions

The possible feasibility of replacing the dominant logic of throwing away the plant after each maguey exploitation system (leaf, *mixiote*, mead) with a circular model (traceability) in which all waste can be used and transformed into tangible resources (biomass) is demonstrated. The maguey plant may again be the most profitable resource given the large number of products that can be obtained and the growing demand that each of them has (Narváez *et al*., 2016). It must be said that science must continue to work on the level of knowledge of the genetic diversity of the maguey for mead/pulque; since, compared to other genera and species, there are limitations, most come from morphological and cytological characters (Gil *et al*., 2001).

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