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Recovery of soil nutrients after the Agave tequilana Weber azul farming in Jesús María, Jalisco, Mexico.

Mexico covers a surface of 1,972, 500 km², where an 11.606% of land can be farming land. With the agriculture, the automobile industry, the petroleum extraction and tourism Mexico's GDP is of \$1,150,887.82 US (The World Bank, 2017). Mexico had a population of 119, 938,473 inhabitants in 2015 established within the 32 states of the country. There are urban and rural zones; the percentage of people that live in urban areas in 2010 was of 77.8%, while the country's population in rural zones has decreased since 1960 to 2010 into 22.2% (INEGI)¹. The most important crops produced in Mexico are: corn, beans, sorghum, onion, pepper, tomato, wheat, sugar cane, orange, banana, lemon and mango. The weather in Mexico can be resumed as warm and temperate, but it depends on its geography and the season, for example, in the North of Mexico the temperatures could be more extreme in summer or winter than there are in the center of the country.



Img. 1: Geographic Location of Jalisco in Mexico.

Mexico is a country known by the traditional processes to make alcoholic beverages like tequila and mezcal. The Agave tequilana Weber azul is one of the most popular varieties of agaves and more grown agaves in Mexico, constituting a 1.25% of the GDP (SAGARPA, 2017)². In 2016 the production of Agave tequilana Weber azul in Jalisco was of 1,329,000 thousand tons (Padilla, 2017). The Tequila Regulatory Council A.C. is a governmental organization that protects the certificate of origin, the process and the quality of the prestigious Mexican beverage, guaranteeing to the consumer the authenticity of the tequila, as it has done it for the last 25 years in Mexico.

The state of Mexico that I selected is Jalisco is divided into 125 municipalities. Jesús María is located in Los Altos Sur region in Jalisco. The municipality that I chose covers a surface of 665 km², it borders the state of Guanajuato and Jalisco's municipalities Arandas, Ayotlán and Degollado. It has a population of 19,469 people, 8,819 men and 10,650 women. The weather is between a semi-dry and a semi-arid condition, and its economy is based on the agriculture. Furthermore, Jesús María's soil has a clay texture and iron presence, the dominant type of soil for agricultural use is lithosol, which is over rocks and in an acid

¹ INEGI: Instituto Nacional de Estadística y Geografía / National Institute of Statistics and Geography in Mexico.

² SAGARPA: Secretaría de Agricultura y Desarrollo Social / Agriculture and Social Development Secretary in Mexico.

condition. The farming land represents a 49.4% (412.11 km²) of Jesús María's surface (IIEG, 2018)³. There are more than 30,000 hectares cultivated with corn, beans, wheat, cabbage, guava, peach and Agave tequilana Weber azul. Additionally, the livestock products are based on the bovine, porcine, poultry, goat and ovine species.

I decided to choose Jesús María as my example, since it is a little municipality with a great potential and because my grandparents were born in that little town when it was so small that they didn't even have electricity. My grandparents have taught us to love and never forget our roots and origins in Jesús María, where my grandfather worked in the Agave tequilana Weber azul farming more than 60 years ago.



Img. 2: Geographic Location of Jesús María in Los Altos Sur, Jalisco.



Img. 3: My grandfather in an Agave tequilana Weber azul plantation in Jesús María.

An average family size in Jesús María has four members, whose diet consists mainly in corn and beans of their own crops production or local producers. They obtain medical services in one of the 10 medical units located in the town, but 3,939 people don't have access to health services. As a matter of fact, there are 17 of 4,627 homes that lack restroom, drainage system or electric energy (CONEVAL, 2010)⁴.

In the education sector, there are 29 preschools, 60 primary schools and 8 secondary schools. There are also a 10.8% of people older than 15 that are illiterate. Jesús María has a high rate of migratory intensity to the United States and to Mexico City, due to the lack of growth opportunities. There is a 49.8% of the population in Jesús María that present a moderate multidimensional poverty level and a 14.2% that are in extreme poverty (IIEG, 2018).

In Jesús María there are more than 600 hectares with hydric erosion or chemical degradation, that is starting to decline soil's fertility and the lost of topsoil. There are two points in Jesús María where the erosion is perceptible. The worst point with severe erosion is in the limit between Jesús María and the state of Guanajuato. The second point of erosion is in the south of the municipality but in a moderate degree. These points of erosion were caused by the change of land use, firstly the forestal use and then to the livestock and

³ IIEG: Instituto de Información Estadística y Geografía / Institute of Statistical and Geographic Information in Jalisco.

⁴ CONEVAL: Consejo Nacional de Evaluación de la Política de Desarrollo Social / Nacional Council for the Evaluation of Social Development Policy in Mexico.

agricultural use. There are records of this event since 18 years ago and it is getting worse year after year.



Img. 4: An *Agave tequilana Weber azul* plantation of 4 years in Jesus Maria.

Primarily, what contributes to this trend is that the *Agave tequilana Weber azul* is the only plant farmed and it is a very long and a nutrient demanding plantation. Most of *Agave tequilana Weber azul* sowings starts at the beginning of the rainy season. Its requirements are: light soil with clay-loam medium texture, pH between 6.0 to 8.0 and it needs a high concentration of nitrogen, potassium and magnesium. The *Agave tequilana Weber azul* farming must have mild winters and rainy patterns during the 6 to 8 years that the *Agave tequilana Weber azul* needs for growing in order to produce tequila. After one long-term sowing, the land has a huge demand of nutrients, but still with a productive capacity. Each time the owner recycles his land the risk of erosion increases and reaches up to a degree where it won't be capable of producing any crop.

The owners of the land are mostly under a leasing contract with big tequila companies, the landlords receive an average of \$26 US per hectare per year depending on the quality of the soil. Tequila companies put pressure under the lessors with the argument that there is a huge demand of raw materials, what leads the owner of the land to monocultures and to recycle the land.

These practices affect both rural and urban population. As for the rural zone, because each time they farm the same plant, one cycle after the other, little by little the land will become totally infertile. The population that lives in the urban areas is affected in the same way, because if the soil becomes infertile, it will no longer hold all the urban and rural demands of the most essential crops and its population will suffer a hunger crisis. If Mexico misses the possibility of continuing with the farming of *Agave tequilana Weber azul*, it will be a loss of traditions and identity. This can be prevented, although it will need full cooperation between the owner of the land, the tequila companies and the Tequila Regulatory Council, A.C.

My proposal consists in crops rotation between the *Agave tequilana Weber azul* and lentil (*Lens culinaris*). The cultivation of lentil creates a relation rhizobia-legume after the *Agave tequilana Weber azul* growth. The fixation of nitrogen can improve the land condition if the producer's intention is the land recycling with *Agave tequilana Weber azul*.

A study from the Tequila Regulatory Council, A.C. could protect the land as it has the necessary laboratories that can determine the soil's condition after the *Agave tequilana Weber azul* farming in order to avoid any kind of contamination and becoming a counter-productive solution. Depending on the results, the TRC and the owner of the land can decide

if the use of certain fertilizers is suitable. For the low concentration of magnesium, potassium and sulfur, it can be a potassium sulfate fertilizer (K₂O 21-22%, S 21-22%, Mg 10-11%,) or a combination with another compatible fertilizer like diatomic phosphate (N 18%, P₂O₅ 46%) or organic fertilizers with the proper quantity for the nutrients required. The cost of the whole treatment to the land to ensure the quality of tequila and the fertility of the soil can be shared between the TRC, the owner of the land and tequila companies. The TCR could provide the materials and the right fertilizers. The landlord must do what is recommended and accept the materials and fertilizers provided by the TRC. The tequila companies could be more focus on the tequila's process of fermentation and contributing economically to protect the land they rented.

There's another factor that should be considered here, the pollinators such as the nectarivorous/polinivorous bats (*Leptonycteris yerbabuena*) that are exposed to danger. Inside the *Agave tequilana* Weber azul's heart there is a nectar that the nectarivorous bats use to pollinate and feed themselves. The bats use the nectar that can only be obtained through the inflorescence produced by the adult agave after the 6-7



years that the *Agave tequilana* Weber azul needs to grow. The reason they are in danger is because the *Agave tequilana* Weber azul farming is stopped before the 7 years of maturity in order to obtain the agave's heart and produce tequila. This affects the bats because they can't consume the nectar nor transport the pollen to another plant, causing at the same time a decrease of the resistance to diseases, as each main rib of *Agave tequilana* Weber azul has the same genetic code of the mother plant. An alternative to this situation can be that the agave producer could leave between 5-15% of his *Agave tequilana* Weber azul crops grow more than 7 years with little use of insecticides, so the pollinators can make their job with the adult plant. The bats have just recently started to be protected by a project called *Bat Friendly* who counts with some producers in Jalisco and Michoacán.

The *Rhizobium* is a photoautotroph bacteria that joined with a legume is capable of developing a symbiosis called rhizobium-legume and transform the air nitrogen into nitrogen that can be resourceful by soil and plants, this process is called nitrogen fixation that occurs on the legumes' roots, just when they are together is that in a reciprocity condition the *Rhizobium* attaches nitrogen and the legume provides coverage and some sugars.

I thought the lentil could be a good option for the relation rhizobium-legume for the reason that it is a legume with the nitrogen attachment capacity by being in symbiosis. The *Rhizobium* attaches on average 100 kg/ha/year with the specie of *Rhizobium Leguminosarum* *bv. viciae*. An 85% of total Nitrogen that requires the lentil it's attached from the atmosphere to the soil. In Mexico, the states that produce more lentils are Michoacán and Guanajuato and they are mostly cultivated by families with low resources. There is a type of lentil that is the most accepted by Mexican families; the Guanajuato variety lentil and has the same capability of nitrogen attachment. Its vegetative cycle lasts 140 days and a sowing can bear 1,800 to 2,200 kg/ha. As a matter of fact, the lentil is a legume with a high nutritional value owing to the

fact that it contains around 25% of protein and 58% of carbohydrates, which are extremely essential to obtain long and short term energy.



img. 6: Guanajuato variety lentil.

Finally, I would like to insist that this crop rotation would not only decrease the hectares that are in an environmental fragility with a high probability of erosion, but this solution is also opening new job opportunities that could change the life of several families in the country. The specie of the bat would be preserved and the living cycle will be continued. At the same time, it would help the *Agave tequilana Weber azul* crops by increasing its resistance to plagues

The lentil farming could be one key element to fight hunger in some Jesús María's localities, where the level of marginalization and poverty are high.

I truly believe this proposal of modifying certain practices regarding the *Agave tequilana Weber azul* farming will completely transform the dangerous uses that could end with soil's fertility into a more sustainable agriculture that would benefit Jesús María population to a great extend. In the beginning, it might not be simple nor easy solution, but when the ideology changes with evidence, something that could have been complex and expensive, and it will become a simple and affordable solution for this challenge in Jesús María, Jalisco, Mexico.

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Images.

Image 1

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Image 2

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Image 3

Photo taken by: Guadalupe Zaragoza Villalobos in Jesús María.

Image 4

Photo taken by: Carolina Zaragoza Núñez in Jesús María. January 2019.

Image 5

Trejo Salazar, Roberto. Eguiarte, Luis. Medellín, Rodrigo. (2017 septiembre). El tequila y el murciélago: ¿todos somos *Leptonycteris!*. *Oikos* =, p 20-23

Image 6

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