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Incorporation and management of improved avocado in the orchards of Tétela del Volcán, Morelos, Mexico: Case study of Gupo FRUFIDET

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ABSTRACT

Objective: To analyze the process of incorporating improved varieties of avocado (*Persea americana* Mill.) and its effect on the diversity, management and use in 54 orchards belonging to 25 members of the Rural Production Society of C.V. Grupo FRUFIDET in Tétela del Volcán, Morelos, Mexico.

Methodology: A survey was applied to all members of society considering the characteristics of the orchards and the process of incorporating improved varieties of avocado to their orchards. The diversity associated with avocado cultivation was obtained through participant observation and a survey. A typology of orchards was carried out with a principal components analysis.

Results: The improved avocado has replaced the peach crop by 67%, plum 12%, corn and bean 12%, pomegranate 6%, and fig 3%. Three types of orchards were found: those that have replaced the previous crop with improved varieties of avocado (17%), those that have introduced avocado as one more species to their orchard in combination with other fruit trees (53%), and those which are maintained with fruit trees and Mexican varieties of avocado (30%).

Conclusions: The improved avocado varieties have been incorporated by 100% of the members of the organization. Their incorporation has caused the displacement of Mexican varieties of avocado and other fruit trees.

Keywords: Mexican varieties of avocado, improved avocado, diverse orchards.

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INTRODUCTION

Avocado (*Persea americana* Mill.) is the second highest agrifood product sold by Mexico, with a surface sown of 241 140 ha in 2020, and a production of 2 388 615 t, maintaining constant growth (Banco de México, 2018; SIAP, 2021). The Association of Avocado Producers and Packers in Mexico (*Asociación de Productores y Empacadores de Aguacate de México*, APEAM) has exceeded one million tons sent to the United States, positioning Mexico as the main producing and exporting country of avocado (APEAM, 2021).

Image by Daniel Dan outsideclick at Pixabay

The state of Morelos is the fifth avocado-producing state with a surface of 5731 ha and a production of 50 402 t, in 13 municipalities, among which Ocuituco and Tétela del Volcán stand out with a surface of 2082 and 1820 ha and a productivity of 17 814 and 16 867 t, respectively. Together, they contribute 89% at the state level (SIAP, 2020).

According to SIAP data, 715 ha were found in 2003 sown with the avocado crop in the municipality of Tétela del Volcán increasing its surface to 1820 ha in 2020.

Avocado has become a crop of economic and social importance in the producing zones, although its expansion in some cases has environmental effects such as degradation and contamination of soils, inefficient use of inputs, and water contamination (Gavito Pardo *et al.*, 2011). The generation of direct and indirect jobs is attributed, positively, to the increase in surface sown with avocado; however, 690 ha of forest zones are deforested annually for its establishment. This generates important implications in the functionality of ecosystems (INIFAP, 2012).

The Mexican varieties of avocado (native avocado) play an important role for the success or failure in the establishment of commercial orchards of this crop (Castro *et al.*, 2003), since they are used as rootstock to obtain a quality plant (Castro & Fassio, 2015). This places at risk the genetic diversity of avocado and causes the disappearance of native and semi-wild materials (Sánchez, 1999).

The increase of the avocado crop, in monocrop, causes the loss of diversity in producing zones (Rosset & Martínez, 2016). This restricts the appearance of weeds and their role in erosion control and nutrient recycling in the soil, nitrogen fixation, by some legumes. Likewise, their use as food or medicine and the attraction of pollinators is limited (Merlín-Uribe *et al.*, 2014).

This study analyzed the process of incorporation of improved varieties of avocado (Hass, Méndez, Jiménez and Fuerte) and its effect on diversity, management and exploitation of the orchards, through their characterization and categorization, taking as case study the orchards that belong to the producers of Group FRUFIDET (Fine Fruits and Byproducts from Tétela del Volcán, *Frutas Finas y Derivados de Tétela del Volcán*).

MATERIALS AND METHODS

Tétela del Volcán meets the current of the Amatzinac Ravine, which originates from the skirts of the Popocatépetl Volcano, northeast of the state of Morelos. Its geographical location is 18° 57' latitude North and 98° 14' longitude West, at an altitude of 2040 masl. There are many climates: temperate sub-humid with summer rains, of highest humidity (73.4%), semi-cold sub-humid with summer rains, of highest humidity (19.37%), semi-warm sub-humid with summer rains, of medium humidity (6.48%), and high altitude cold with marked winter (0.75%) (INAFED, 2020; INEGI, 2009). Tétela del Volcán has an approximate surface of 98.61 km^2 distributed in 3035 ha for agricultural use and 6602 ha for forest use. The soils are deep, rich in minerals and nutrients. The fertility and organic matter content are limited, most of the orchards present slopes over 20% given the uneven orography of the region, in addition to soil erosion (Márquez Berber & Colinas León, 2019).

The study was conducted with the Rural Production Society of C. V. Grupo FRUFIDET, made up of 25 producers/ras. The field work was carried out in March and April 2021, through a mixed methodology strategy that involved all of the members. A survey was applied through a questionnaire with the following sections: general data, characteristics of the orchards, adaptation of improved varieties of avocado, management of orchards, and diversity associated to the avocado crop. The data were processed through the software Excel 2010 and SSPS version 24 for the elaboration of graphs, and a principal components analysis. In addition, participant observation, visits and tree registry were conducted within each of the orchards.

RESULTS AND DISCUSSION

The society started in 2003 with 320 producers, and currently there are 25 from which 14 have been in it since the beginning, while the rest became integrated through time. Grupo FRUFIDET is made up by 22 men and three women with an average age of 54 years, a minimum of 20 and a maximum of 89. The grade of studies of the producers is four with Bachelor's degree, six with high school, five with secondary school, five with primary, and five do not know how to read and write.

Agriculture is the occupation that 76% of the members carry out as main activity, and 24% as second option. The agricultural surface as a whole has an extension of approximately 60 ha, with an average of 2.4 ha, and two orchards per producer on average. The minimum surface of a producer is 0.25 and the maximum four ha. However, because of land fractioning, the ownership of the orchards varies, from those who have two (11), one (6), three (6) and four orchards. The producers with two or more orchards cultivate improved varieties of avocado as monocrop and in association with other crops.

Avocado in the orchards of Tétela del Volcán

In the survey the producers indicated that they have historically cultivated different fruit trees (peach, plum, blackberry, sweet granadilla, pear, fig and avocado), although the fruit trees of greatest profitability and persistence in time were peach orchards and then the improved varieties of avocado. Peach was a crop of high economic importance at the local and regional level, allowing for members of the Grupo FRUFIDET to recognize themselves as producers and traders of this fruit. In this regard, Chávez & Chávez (2006) mention that in 2004 they had a record of 2500 ha with peach crop in the municipalities of Tétela del Volcán, Ocuituco, Zacualpan de Milpas, and Tlacotepec, of which 850 ha correspond to Tétela del Volcán (SIAP, 2004).

In 2005 the produces from Tétela del Volcán began to have problems with pests and diseases, among which the following stand out: a) damage from nematodes (*Dorylaymus*, *Tylenchus*, *Aphelenchus* and *Pratylenchus*) (González Cortés *et al.*, 2010; Meza Durán, 2019); b) San Jose scale (*Quadraspidiotus perniciosus*), and c) white root rot (*Armillaria mellea*). Another frequent problem is the presence of aged plantations and the lack of an integral management of the crop. The previous problem caused for producers to seek other alternatives for growth (*Eng. Rolando Mendoza, Personal communication, April 19, 2021*). They incorporated improved varieties of avocado gradually in their orchards. Eight producers did it between

1980 and 2000, five from 2001 to 2005, and the last producer of the group who introduced avocado did it in 2017, with which 100% of the producers cultivate improved varieties of avocado (Figure 1).

The surface with which the producers began growing avocado was: 0.5 ha (12); 0.6 to 1 ha (eight); 1.1 to 2 ha (four); and 2.1 to 5 (one); 17 producers mentioned that they began testing with a few trees. According to the information obtained, from the years 2014 to 2019, 68% (17) of the producers mentioned having increased the sowing surface with improved varieties of avocado, 20% (five) conserve the same surface area that they started with, and 12% (three) decreased it due to issues of adapting to the place or presence of *Phytophthora cinnamomi*. Currently, the improved varieties are represented as follows: 46% Hass, 36% Jiménez, 15% Méndez, and 3% Fuerte.

Tree composition of orchards

The producers have a total of 54 orchards, from which 85% include improved avocado, followed by 9% plum, 4% fig and another 2% is represented by avocado of the Mexican variety. The improved varieties of avocado are the main source of agricultural income for members of Grupo FRUFIDET due to the permanent commercial demand for the product and because the producer schedules the cuts and the harvest according to their economic needs, which agrees with Rubí *et al.* (2013) who mentioned that the adoption of Hass avocado from producers of the south zone of the state of Mexico, happened because of its easy commercialization and high acceptance in the market, resulting in important economic revenues for producers.

From the orchards, 14% (seven) do not have improved avocado varieties; seven maintain a monocrop with plum (five) and with fig (two). In contrast, there is a single orchard (2%) that conserves Mexican avocado varieties. Generally those who have a single orchard present tree diversity, with the exception of one producer who has improved avocado in monocrop. However, those who have more than one orchard manage improved avocado varieties, Mexican varieties, and other fruit trees in different modalities of the crop (monocrop, associates, interspersed, in lines, etc.).

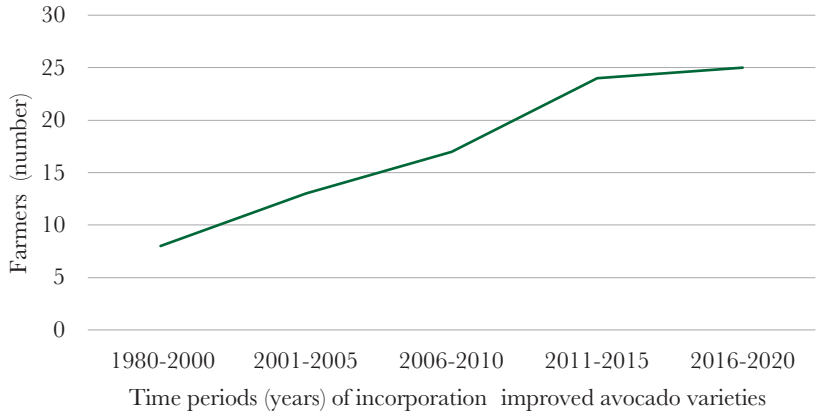

Figure 1. Process of incorporation of improved avocado in the orchards of 25 producers from Grupo FRUFIDET during the period of 1980 to 2020. Source: prepared by the authors with field data.

The 46 orchards present six types of arrangements (Figure 2): a) Orchards with improved varieties of avocado in combination with other fruit trees (peach, plum, apple, walnut, Colombian pomegranate, pear, blackberry, custard apple, lime, black cherry, loquat, star fruit, guava, orange, papaya and quince) and annual crops (oat, maize and pea); b) with improved avocado varieties in combination with Mexican varieties, other fruit trees, and annual crops; c) with improved avocado; d) six orchards with Mexican varieties in combination with improved varieties; e) with fruit trees in monocrop (five with plum, two with fig, and one with Mexican variety of avocado).

According to Guzmán *et al.* (2017as the center of origin of avocado (*Persea americana* Mill.), the geographic dispersion of improved varieties of avocado is attributable to the presence of Mexican varieties which are adapted to each local environment, and this has reduced the populations of Mexican varieties to give rise to improved ones, since the first are used as rootstock because they have genes resistant to pests and diseases. The substitution of Mexican varieties for improved ones, plus the destruction of habitats, place at risk the Mexican varieties of avocado and diversity in general (Rincón-Hernández *et al.*, 2011; Sánchez, 1999).

The importance of the diversity of Mexican varieties of avocado consists in their use to form family orchards, to later select seeds that are used in commercial nurseries as rootstock (Bellón *et al.*, 2009). However, scarce interest has been shown in the classification and conservation of germplasm that allows the protection of this national heritage of diversity, and the conservation of different genotypes of Mexican varieties that nowadays are threatened when they are substituted by improved varieties (Gutiérrez-Díez *et al.*, 2009), which places them at risk of disappearance. In this regard, at the national level, INIFAP and the Salvador Sánchez Colín-CICTAMEX Foundation are the ones that preserve part of the genetic reservoir (Bellón *et al.*, 2009).

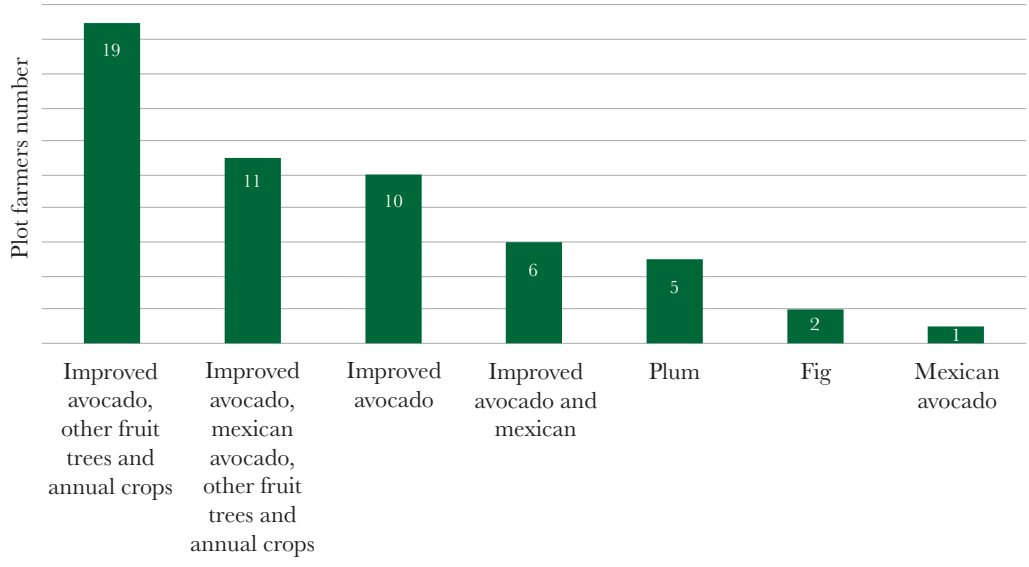

Figure 2. Diversity of orchards in Grupo FRUFIDET, 2021. Source: prepared by the authors with data from field work.

Management of the orchards

To conduct management of the orchards, 15 of the producers (60%) resort to hired technical counseling, particularly for the avocado crop. Eight of them are advised by a technician from the agrichemicals store, five receive it from an independent technician and two from a technician from the State Center of Plant Health from the state of Morelos CESVMOR. The main practices for which they receive support, in order of importance for the producer are: nutrition, pest and disease management, pruning, establishment of the orchard, plant reproduction and commercialization. The specialized technical assistance is useful to obtain quality production and to reduce phytosanitary problems that sometimes affect the sale of avocado (Rubí *et al.*, 2013).

The management practices of the orchards are generally conducted with family labor, although in practices such as application of nutrients, fertilizers, pruning and harvest, 80% of the producers use family and hired labor, 16% only family labor, and 4% depend on hired labor.

Many of the jobs generated by avocado are temporal jobs, particularly at the time of the harvest, although in recent years the possibility has come up of foreign buyers taking their cutters and not hiring local people, generating economic instability for the families, which agrees with what was reported by Macías-Macías (2009).

When it comes to management of the water resource, 23 producers have water for irrigation, 22 do it with water from volcano ice thawing, and one owns a well. For their part, two producers do not have irrigation and take advantage of rainstorms.

Diversity associated to avocado

Merlín-Uribe *et al.* (2014) mentioned that there is evidence that weed management increases the productivity of the crop, in addition to being auxiliary in minimizing the presence and amount of pests. However, Escobedo-Cruz *et al.* (2017) mention that weeds affect the crops, due to competition over water, nutrients and light. However, conserving it as organic padding favors the soil.

In the diverse orchards, it was found that producers have other usable species, so that weeds are allowed in 72% of the orchards, 8% have another annual crop in the space between lines of avocado, and 20% mentioned using herbicides to keep the soil clean.

The usable species that were part of the inventory of the orchards are used as: a) Food: violettas (*Anoda cristata*), amaranth (*Amaranthus* sp.), pomegranate (*Punica* sp.), turnip (*Brassica rapa*), thorny amaranth (*Amaranthus spinosus*), jocote (*Spondias purpurea*), purslane (*Portulaca oleracea*), huauzontle (*Chenopodium nuttalliae*) and fig-leaf gourd (*Cucurbita ficifolia*); b) Medicinal: rue (*Ruta graveolens*), basil (*Ocimum basilicum*), lavender (lavándula) and kidneywood (*Eysenhardtia polystachya*); c) Boundary or firewood: cedar (*Cedrus* sp.), oak (*Quercus* sp.), ocote (*Pinus moctezumae*) and oyamel fir (*Abies religiosa*); and d) Fodder: wild radish (*Raphanus raphanistrum*).

In general those who leave the weeds do it to favor bees and other pollinators, according to their testimonies. The conservation of other species in the orchard, which are also used, signals the possibility of conducting agro-forestry practices that can be an option to increase the productivity and profitability of the orchards. It has been proven that by having more

biological diversity, more environmental and economic benefits are obtained (Montiel-Aguirre *et al.*, 2008).

Characterization

The characterization of producers carried out considered the following variables: surface and slope of the orchard, presence of improved varieties of avocado, Mexican varieties, other fruit trees, irrigation, and usable species. The analysis differentiates two groups of orchards, where diversity is one of the most important variables (Figure 3).

Group one or diverse orchards (76%) manages more than one species of fruit trees, having improved avocado varieties (20-450 trees), and in addition manages other fruit trees and Mexican varieties. They have surfaces between 0.2 and 1.5 ha, gentle to pronounced slopes (more than 20%).

In the various orchards the risks from climate effects can be decreased, the soil fertility favored, the erosion decreased, and the agricultural income diversified; this agrees with what was shown by Nataren-Velazquez *et al.* (2020).

The members of group two, which is equivalent to non-diverse orchards (24%) have surfaces of 1 to 2.8 ha, gentle to pronounced slopes over 20%, trees of improved varieties (from 500 to 625 trees), irrigation systems and weed control.

CONCLUSIONS

Improved avocado varieties have been incorporated by 100% of the members of Grupo FRUFIDET, and their integration to the orchards has been as monocrop, associated crop or interspersed with other tree species, annual crops, and other useful species. The incorporation of improved avocado varieties has caused the displacement of Mexican varieties of avocado, due to their importance as rootstock; however, they are placed at risk

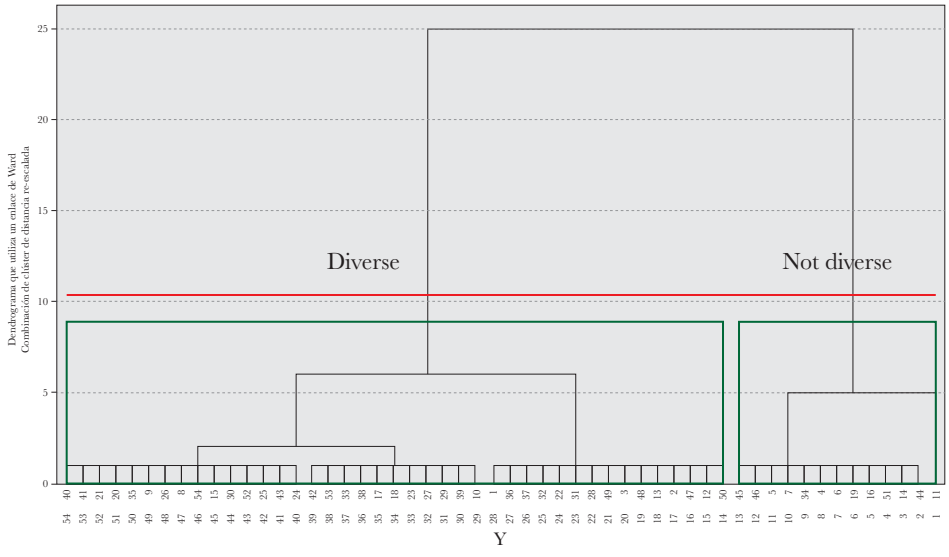

Figure 3. Typology of orchards from Grupo FRUFIDET.
Source: Prepared by the authors with data from field work.

from not being valued as genetic reservoir. The members of Grupo FRUFIDET manage diversified systems as a strategy for the exploitation of other species that are used as food, medicinal, boundaries, firewood; in addition, they avoid erosion and favor pollinators.

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