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Description

This Journal publishes original articles, short and technical notes and review articles in all fields of botany, and the biology of soils or terrestrial and aquatic plants. Manuscripts reporting results of descriptive, historical and experimental studies on any aspect of botany, and soil or plant biology, and at the scale of organism, population, community, ecosystem and landscape are solicited, as well as manuscripts on ecological theory.

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Descripción

Esta revista publica artículos originales, notas cortas y técnicas, y artículos de revisión en todos los campos de la botánica y de la biología del suelo, y de las plantas terrestres y acuáticas. Se solicitan manuscritos que informen resultados de estudios descriptivos, históricos y experimentales sobre cualquier aspecto de la botánica o biología del suelo y de las plantas, a escala de organismos, poblaciones, comunidades, ecosistemas y paisajes así como también de teoría ecológica. *Phyton, Revista Internacional de Botánica Experimental* también publica Actas de Simposios, Tesis y comentarios sobre manuscritos recientes publicados en la revista.

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- c. Schematic representation of the epidermis showing the cuticle, integrated by the cuticle itself (CP) and the cuticle layer (CL) covered by ECW.
This figure is part of the thesis work of Lic. M.Sc. Clara Franchini, and it is related with her article in the current volume of *Phyton*: Franchini MC, LF Hernández, LI Lindström. Cuticle and cuticular wax development in the sunflower (*Helianthus annuus* L.) pericarp grown at the field under a moderate water deficit. *Phyton* 79: 153-161.

• Ilustración de tapa:

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- b. Sección transversal del pericarpo de girasol mostrando la distribución de sus partes constitutivas. b1. Células epidérmicas cubiertas por una cutícula delgada. b2. Hipodermis. b3. Capa de fitomelanina. b4. Capa media con radios parenquimáticos (r). b5. Epidermis interna. Escala = 200 µm.
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La figura es parte del trabajo de Tesis de la Lic. M.Sc. Clara Franchini, y está relacionado con su artículo en este volumen de *Phyton*: Franchini MC, LF Hernández, LI Lindström. Desarrollo de la cutícula y ceras epicuticulares en el pericarpo de girasol (*Helianthus annuus* L.) bajo déficit hídrico moderado en condiciones de campo. *Phyton* 79: 153-161.

West Indian avocado: where did it originate?

Aguacate Antillano: ¿dónde se originó?

Galindo-Tovar¹ ME & AM Arzate-Fernández²

Abstract. Origin of West Indian avocado has been explained by current-day factors, such as abundance patterns; however, it is still unclear where it originated. Anyhow, there is a history behind the species that reflects, in one way or another, the present geographic distribution and species characteristics. We examined paleohistorical and paleoecological data to explore the West Indian avocado origin. Our results suggest that West Indian avocado originated by domestication and ecological adaptation in the Maya Lowland area; this is where this botanical variety of avocado has an ancient history.

Keywords: Avocado; *Persea americana* var. *americana*; Maya Lowland; Origin; Dispersion; Maya culture.

Resumen. El área de origen del aguacate Antillano ha sido explicada en base a factores del presente, como los patrones de abundancia. Sin embargo, aún no está claro donde se originó esta variedad botánica del aguacate. De todas maneras, hay factores históricos de la especie que reflejan, de una u otra forma, su distribución geográfica actual y las características de la especie. En esta investigación se han examinado datos paleohistóricos y paleoecológicos para explicar el origen del aguacate Antillano. Los resultados sugieren que la variedad botánica del aguacate Antillano se originó por domesticación y adaptación ecológica en las tierras bajas Mayas, donde esta variedad de aguacate tiene una antigua historia.

Palabras clave: Aguacate; *Persea americana* var. *americana*; Zonas bajas de la civilización Maya; Origen; Dispersión; Cultura Maya.

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INTRODUCTION

Cultivated avocado (*Persea americana* Mill.) is composed of three botanical varieties, each with its own genotype characteristics: *Persea americana* var. *drymifolia* (Schltdl. & Cham) S.F. Blake (Mexican avocado) is adapted to the tropical highlands; it is characterized by a relatively good cold tolerance and small fruits that are covered by a thin, purplish-black skin; *Persea americana* var. *guatemalensis* (L.O. Williams) Scora (Guatemalan avocado) is adapted to medium elevations in the tropics; it is somewhat cold tolerant, and the fruit has a thick, tough skin. *Persea americana* Mill. var. *americana* (West Indian avocado) is adapted to the lowland humid tropics, with salt and chlorosis tolerance; its fruit is round to pyriform, has a smooth, easy-to-peel skin and abundant flesh, with an almost sweet taste not found in the other two varieties (Williams, 1976; Bergh & Ellstrand, 1986; Barrientos & López, 1998). At present, commercial avocados are selections from these three varieties, and hybrids among them (Chanderbali et al., 2008). According to Chen et al. (2009), the three avocado botanical varieties originated when avocado populations became isolated for long periods of time prior to human utilization of the species. When humans started to consume the fruit, domestication *in situ* was initiated, and subsequent wide fruit dispersion occurred. Even though substantial genetic differentiation among the three botanical varieties has been observed, using molecular markers (Chanderbali et al., 2008) and sequences of nuclear *loci* (Chen et al., 2009), much work remains to be done to understand the origin of the three botanical varieties of avocado.

The three avocado varieties seem to have originated in different regions (Storey et al., 1986) as a result of their domestication by different human groups, and ecological adaptation to different climates. However, their origin still remains obscure (Clegg et al., 1993). The three avocado botanical varieties show profound historic roots in Mesoamerica since pre-Columbian times (Galindo et al., 2008). This means that documenting the historical context and relating it to climate, vegetation and human activities will help to understand the origin of the avocado botanical varieties and its relationship with the domestication of the species. This is especially true when there are few archaeological references as a result of the fast destruction of organic plant remains in tropical humid climates, prevalent in Mesoamerica area.

Of the three varieties, the origin of the West Indian is one of the most questioned, and at present there are still discrepancies about its center of origin. Williams (1976; 1977) proposed that the West Indian avocado originated from a selection within the Mexican avocado in a place somewhere along the mountains and lowlands of east central Mexico, from 3000 – 2000 B.C. He also argued that the presence of the West Indian avocado on the coasts of Peru 2000 – 1000 B.C. suggests its early origin and dispersion from Mexico to Peru, which occurred in a period between 200 to 300 years.

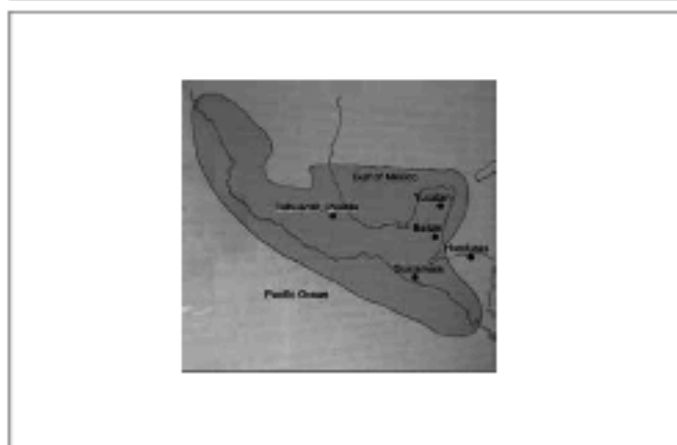
Storey et al. (1986) agreed that the three avocado botanical varieties originated because of geographical isolation and with human intervention. However, these authors located the center of origin of the West Indian variety in the Pacific lowlands in Central America (from Guatemala to Costa Rica). Even though their arguments are circumstantial and lack important information, the Central America west lowlands origin for the West Indian avocado is widely accepted. We urge investigation of neglected historical information (i.e., chroniclers' descriptions as well as integration of archaeological data) that reports about the relationships among the ancient groups that inhabited the present avocado dispersion area. In this investigation, we have reconstructed West Indian avocado history. We examined the Maya Lowlands (Yucatan, Mexico and Belize) as the West Indian avocado center of origin; we used archaeological and paleoecological data, as well as references from chroniclers for the presence of avocado on the east side of Central America and in northern South America before the arrival of the Spanish.

West Indian Avocado origin

The most ancient information on the avocado in Mesoamerica (Fig. 1) are the seed remains reported by Smith (1966; 1969) in Tehuacan Valley (Puebla, Mexico), dating from approximately 8000 B.C. Their morphological characteristics indicate that these were Mexican avocados, and the association with human fossils suggests that they were consumed by humans since that time.

Fig. 1. Área de Mesoamérica (sombreada) que muestra los principales sitios relacionados con el origen de la variedad botánica Antiliana del aguacate (*Persea americana* Mill.).

Fig. 1. Mesoamerica area (shaded) that shows the main sites related with the origin of the West Indian botanical variety of avocado (*Persea americana* Mill.).



Man-avocado interaction began when the first groups of nomadic humans came to Mesoamerica. It is likely that the Mexican avocado dispersal towards other areas began at that time. The cultural and economic interregional interaction among the ancient cultures inhabiting the Gulf of Mexico and the inland (Marcus, 2003; Pool, 2006) suggests the peninsula

of Yucatan as one of the avocado dispersion areas. It is difficult to know the state of domestication of the avocado carried to Maya lowlands in Yucatan and Belize. However, it seems that this avocado was domesticated in this area, originating the West Indian botanical variety, and not in the Pacific lowlands as suggested by Storey et al. (1986).

This idea is supported by the following evidence:

- i. There are archaeological data, since the Paleoindian period (c. 8000 – 6000 B.C.), from human groups in the Maya region, particularly in Belize (Marcus 2003). In addition, Colunga & Zizumbo (2004) dated the first indications of agricultural activities in the Maya Lowlands back to 3400 B.C. Even before this date, there is also evidence of the introduction of species domesticated in other cultural areas of Mesoamerica, including the avocado.
- ii. The avocado has been valued by the Maya culture, not only as food but also as a part of their culture. For example, the Maya developed the Haab calendar (civil calendar), between 300 and 800 years B.C. This was an agrarian calendar, where the names of the months represented seasonal and agricultural events. In this calendar, the 14th month was represented by a glyph symbolizing the avocado. The Mayas called this glyph *Uniw* or *Uniiw* in their own language, that corresponds to *K'ank'in* in the Yucatec of the 16th century, meaning day, sun or time (Landa, [1560]1978; Kettunen & Christophe, 2004). Another interesting example of the Maya-avocado relationship was found in the king Pacal tomb inscriptions in Palenque, Chiapas, Mexico. This tomb was built in A.D. 650 and on both sides of the sarcophagus there are 10 figures that represent the ancestors of Pacal; behind each of them there is a tree. Behind the only feminine figure, Lady *Olmal*, a tree emerges with avocado fruits hanging from its branches. These figures may represent a forest around the Maya homes, where the main fruit trees were cultivated as a food source, and also because the Mayas thought that their ancestors were reborn as trees (Schele, 1974; Schele & Mathews, 1998; Schele & Stuart, 1985).
- iii. Two important chroniclers of the New Spain, Landa ([1590]1978) and Cobo ([1653]1956), described avocados resembling the West Indian type. They reported that West Indian type avocados were consumed by the inhabitants of Yucatan before the arrival of the Spanish.

Friar Diego de Landa in "Relación de las cosas de Yucatán" referred to the flora of Yucatan, and described the avocado as:

"un árbol muy grande y fresco al cual llaman los indios on; lleva una fruta como calabacillas grandezuelas de gran suavidad que parece a sabor manteca y es mantecosa, y es de muy gran mantenimiento y sustancia. Tiene gran cuenco y delicada cáscara, y cómese cortado en rebanadas como melón y con sal".

[“a very big and cool tree which the Indians call *on*; it has a fruit like a courgette of great smoothness that seems to flavor buttery, and is of very great maintenance and substance. It has big seed and delicate rind, and people eat it in slices like melon and with salt”].

Friar Bernebé de Cobo in "Historia del Nuevo Mundo", described the different types of avocados and referred to the West Indian avocado in the following form:

"...la Palta es un árbol de apariencia muy atractiva, bien formado del tamaño de una gran biguera, de ramificación simétrica y moderadamente amplio; sus hojas son similares a las de la mora, no muy amplias y sus frutas unas de las mejores de las Indias: de hecho, muchos la ponen antes que todas, de forma alargada y del tamaño promedio de un membrillo; en algunas regiones es tan grande como una calabaza pequeña o una toronja grande, las variedades de la provincia de Yucatán (Nueva España) son de esta clase. La palta tiene cáscara delgada, más suave y flexible que el limón Ceuta, verde por fuera, y cuando la fruta está bien madura, se pela fácilmente. Tiene la semilla más grande que haya visto en cualquier fruta, aún en las Indias de Europa... Entre la semilla y la cáscara se encuentra la carne, un poco más gruesa que un dedo excepto en el cuello donde es más gruesa. Es de un color verde blancuzco, delicada, mantequillosa y muy suave. Algunas gentes la comen con azúcar y sal, otras directamente del árbol, tiene un sabor tan bueno que no requiere de sazonzarse..."

[“The Palta in Yucatan is a tree of very attractive appearance, of the size of a large fig tree, with symmetric branching and moderate width; its leaf is similar to that of the mulberry, not too wide, and its fruit is one of the finest in the Indies; in fact, many place it before all others, in some regions it becomes as big as a small squash or large citron; the varieties of the Yucatan region (New Spain) are of this type. The Palta has a thin skin, more tender and flexible than that of a Ceuta lemon, green externally, and when the fruit is very ripe, it peels readily. It has the largest seed I have ever seen in any fruit, either in the Indies or Europe. Between the seed and the outer skin is the meat, slightly thicker than one finger except at the neck where it gets thicker. It is of whitish green color, tender, buttery, and very soft. Some people eat it with sugar and salt, others just as it comes from the tree, it has such a good flavor that it requires no seasoning”].

The Maya culture has been recognized as one of the principal domesticators of the avocado (Gama & Gómez, 1992). Thereafter, it may be that the avocado, under their management, adapted to the Yucatan tropical conditions of climate and soils, formed on the limestone bedrock of the Maya Lowlands, acquired its characteristics for salinity and chlorosis tolerance, and thus originated the West Indian variety. According to Storey et al. (1986), the avocado did not originate in the east side of the Americas because: “1) the avocado was not known in the Antilles before the arrival of the Spanish, since there are no reports of it by chroniclers and botanists, 2) if the West Indian avocado had originated from the east side of the

continent, it surely would have spread towards the Antilles long before the arrival of the Spanish". However, there are reports that when the Spanish arrived in Yucatan (early 16th century), the Maya culture was different from the Caribbean (Andrews, 1993). This indicates little if no contact between them. This explains the absence of avocados in the Caribbean islands until it was disseminated by Balboa.

On the other hand, the interregional interaction among the different cultures that inhabited the Gulf Coast of Mexico and the rugged inland and beyond, has been widely studied. The dynamics of human occupation in this area indicates independent ties to contemporaries in distant resource zones and along trade routes (Pool, 2006). In addition, according to Marcus (2003), trade activities linked the human groups from Veracruz to Yucatan, Honduras and beyond.

West Indian Avocado dispersion

Evidence presented in this paper indicates that the West Indian avocado was originated in the lowlands of Yucatan and Belize, and it was then carried to Central and South America. For Lesure (2008), horticultural activities started in Mesoamerica in the Archaic period, and crop plants spread as far as South America before emergence of formative village life.

First dispersions of West Indian avocado very likely happened when some early Maya groups of the Yucatan peninsula migrated eastward across the coast, coming up to Honduras (Marcus, 2003). Evidence for the presence of the West Indian avocado in Honduras are the seed remains found in Rio Claro, which indicate that the Papayeca Culture was consuming it around 1200 to 1000 B.C. (Healy, 1978). There is also information that indicates the arrival of human groups to North-Eastern South America (Colombia) as early as 11000 B.C. (Oyuela-Caycedo, 2008). In addition, the presence of avocados in Yaharo (Colombia) before the Spanish arrival was documented by Fernández de Enciso in his book "Suma de Geografía" ([1519]1546):

Antes de llegar a Santa Marta está Yaharo que es en las caídas de las sierras nevadas. Yaharo es buen puerto y buena tierra y aquí ay heredades de arboles de muchas frutas de comer y entre otras ay una que parece naranja, y cuando está sazónada para comer vuelvase amarilla; lo que tiene de dentro es como manteca y es de maravillosa sabor y deja el gusto tan bueno y tan blando que es cosa maravillosa."

[“Before reaching Santa Marta is Yaharo, which lies at the foot of the snow mountains. Yaharo is a good port, with good lands and here are groves of many different sorts of edible fruits; among others is one which looks like an orange, and when it is ready for eating it turns yellowish; its composition is like butter and is of marvelous flavor, so good and pleasing to the palate that it is a marvelous thing”].

Furthermore, Pope et al. (2001) reported that the presence of *Manibot* sp. in Tabasco, Mexico, from 4600 B.C., indicates

the indirect contact of the settlers of this area with those of the basin of the Amazon.

The presence of the avocado in northern South America has also been described by other chroniclers: Carvajal ([1542]1999) in the Peruvian Amazona, and Juan & Ulloa ([1748]1970) in Ecuador, described avocados with the West Indian characteristics. Avocado seed remains, going back as far as 2500 to 1800 B.C. have been reported in the Moche Valley, Peru (Pozorski, 1979), and on the Peruvian Pacific coast at least since 1500 B.C. (Heiser, 1979). Likewise, Skidmore (2005) reported that the Caral culture (Supé Valley, Peru) was consuming domesticated avocado at 1200 B.C., even before maize. All this evidence indicates dispersion of the avocado from North-Eastern South America to Ecuador and Peru, at North-Western South America.

There are two hypotheses with regard to the presence of the West Indian avocado in the Central American Pacific side: (1) it can be explained by a migration route from Belize to the Guatemalan lowlands and to the Pacific coast. This is where the Yucatan West Indian avocado could have been either carried or domesticated again. This hypothesis is supported by the close interaction among the Maya lowlands, central Mexico areas and the Isthmus of Tehuantepec with the Izapan and other Guatemalan cultures since the Classic period (Pool, 2006). The Guatemala highlands seem to have been a geographic and temporal bridge between the Early Preclassic villages of the Chiapas coast and subsequent lowland cities (Marcus, 2003). (2) The avocado was dispersed from Ecuador to Central America (Wolters, 1999). This author suggested that the avocado was exchanged together with other crops along the coasts of northern South America and Central America about 2200 B.C., during the coastal travels realized by the Valdivia culture along the Pacific coast.

CONCLUSION

Current data allow us to reconstruct the events and processes of the avocado relationship with the Maya Lowland culture and its dispersion. The history behind the species, its interaction with ancient human groups, and archaeological data indicate the Maya Lowlands as the center of origin for the West Indian botanical variety. Its tolerance to salinity and chlorosis must be the result of the avocado adjustment, under human guidance, to the climatic and soil conditions of the peninsula of Yucatan, resulting in its domestication. Finally, archaeological information and the interactions among the different cultures can explain its dispersion to Central America and northern South America. Nevertheless, ethnobotanical, historical and molecular data, continues to be necessary to determine the phylogeographic relations among the modern avocados.

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