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A Study of the Avocado Germplasm Resources, 1988-90. I. General Description of the International Project and its Findings

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***Abstract*. The study and conservation of avocado genetic resources are of common interest to the industries of different countries due to the rapid disappearance of such resources. For this reason, the project is based on international cooperation, with the moral support of the IBPGR, and financial support from the GIARA fund.**

The activities include: (a) a study of native populations; (b) collection of representatives of the populations and interesting individual resistant trees; (c) propagation of the collected material; (d) conservation of the material in germplasm banks; (e) a biochemical study of avocado phylogeny, using RFLP and isoenzyme methods; and (f) evaluation of the collected material for horticultural use.

Some of these activities are described by our team members in other papers in this publication. In the present article, we include a general description of the project and some results of our survey in Latin American countries other than Mexico.

The avocado fruit has a very high nutritional value and development of avocado orchards would be important for the diet of human beings, and also for economic reasons. However, the avocado tree is very sensitive to both climatic and edaphic factors. Low productivity due mostly to climatic factors, and poor growth due mainly to soil factors, limit the development of this unique fruit tree in wide areas of tropical and subtropical regions of the world.

The avocado is native to Mexico and Central America, and tens of thousands of seedling trees grow there under highly varied ecological conditions. Natural selection over thousands of years has produced types suitable for these regions. This vast population, when used as varieties, rootstocks and breeding materials, is invaluable for

the development of orchards under stress conditions. Great diversity was not typical of selection and breeding programs of avocado in the past, as these programs were conducted in the countries where the avocado was introduced, and not in the countries of origin. Only when avocado root rot became the main problem of the industry in California, were more introductions made.

During the last two or three decades, the native and semi-wild avocado material has been disappearing rapidly, like many other native species, and often even faster. Some know reasons for this are: The use of the wood for rapidly growing human populations (who need the land also for corn and other food crops), fires, soil diseases, and the grafting of seedling trees. There are important reasons to stop the eradication of the forests, but nobody is very optimistic about the success of this effort. For the avocado, it is critical to conserve as many native types as possible and to study their importance for the cultivation of avocado. This was the reason and aim of this study.

Materials and Methods

Exploration

1. A study of the ecological conditions of the regions of origin.
2. Evaluation of the density and composition of tree populations.
3. Identification of wild material and primitive varieties.
4. Locating particularly interesting individual trees.
5. The role of Persea as a member of native plant societies.

Collection of plant material

1. For new varieties: collection of local selections throughout the surveyed countries.
2. For new rootstocks: collection of vegetative material of particularly interesting individual trees and seeds of interesting populations.
3. For hybridization and conservation, any material with valuable characteristics.

Conservation

Mother plantations (germplasm banks) were established in Mexico, Costa Rica and Israel. Each orchard includes active and passive plots, which differ from each other in the distances between the trees. The active plot is the source of material for further propagation.

Evaluation of the collected material includes:

1. A study of its propagative characteristics.
2. A study of the roostock-scion relationships.
3. A study of the behavior of new varieties in different areas of the different countries.
4. A study of the collected material as seeded and clonal rootstocks for various soil conditions.
5. Developing hybridization work for the confirmation of special characteristics.

Biochemical study

For the study of the phylogeny and classification of the avocado and its relatives, biochemical methods such as RFLP and isoenzymes are used. These methods are essential also for the identification of the native types in regard to genus, species, variety and race.

Literature survey

A vast literature survey of the subject has been done. This survey will be summarized in the final report of the project (May, 1992) and in a separate article.

Results

This project commenced in 1988 and intermediate reports were presented at the 2nd World Avocado Congress, as follows:

1. General description of the international project and its findings (by A. Ben-Ya'acov, Israel).
2. Ribosomal DNA repeat unit polymorphism in avocado (by G. Bufler, Germany).
3. Findings in the Mexican Gulf (by A. Barrientos, Mexico),
4. Findings from the highlands of Mexico (by E. De La Cruz, Mexico).
5. Evaluation of the collected material for horticultural purposes (by Miriam Zilberstaine, Israel).

Regions surveyed

Mexico. In Mexico, one team explored the Mexican Gulf states -Vera Cruz, Tamaulipas, Tabasco and Yucatan, and also the State of Chiapas. The details are included in the article by A. Barrientos-Priego in this volume. This area may have been the origin point of the Mexican avocado (Vera Cruz) and the Guatemalan avocado (Chiapas), as well as some of the avocado relatives. Another team explored the State of Mexico, Nayarit, Michoacan, Puebia and Morelos (De La Cruz article in this volume).

Chile. In Chile, we explored the Andes near Chilian and Temuco, where we saw and collected 11 different samples of *Persea lingue*, and in the Quillota Valley where we collected *Persea meyeniana*. Both species are called 'Lingue' as the common name. The differences between the two species are very small, but their area of distribution is not the same. *Persea lingue* is distributed in cold and wet climates and is resistant to wet soils. The trees we saw and collected were in the range of 50 to 900 meters above sea level, with about 2000 mm average rainfall. The wood of the 'Lingue' is excellent for the furniture industry, but the fruit is poisonous to cattle. For these two reasons the 'Lingue' trees are disappearing very rapidly, even faster than the whole native forest.

Another interesting tree in central Chile is the 'Belloto', *Bielschmedia mierssi*, a native of this area, which also belongs to the Lauraceae. Seeds were collected from this species as well.

Ecuador. As Ecuador is located on the equator, the different climatic conditions, especially temperature, depend on the elevation which differs among the mountainous colder region, the eastern low altitude, and the western low altitude. The high altitude region was surveyed in the past by Popenoe and by Zentmyer, and we collected material there also in 1977 and 1987. On the present visit, more attention was paid to the lower areas. Besides avocado, some eight other *Persea* species were be found in Ecuador.

The Highland Region: the interesting type here is the "Nacionales", a Mexican avocado well adapted to the soils of this region. This type was re-sampled, while previous accessions are already under evaluation. Some other types which originated in the highlands are also under investigation (see Table 1).

The Western Pacific Lowlands: the typical avocado type identified in this region is said to be West Indian, but we suspect this name, as it is completely different from known West Indian avocados in Central America and Mexico: the trunk's bark is very smooth, the leaves are pubescent, they are bigger and rounder, and the area around the leaf veins is prominent. The trees can reach very large size and are known to be very productive. The fruit is big (600-800 g), either elongated or round. The seed is smooth, as opposed to rough seed of the West Indian avocados known in northern countries. Most of this lowland region of Ecuador has been cultivated, and therefore it is difficult to find native trees. We managed to find and to sample a few trees of this interesting type (Table 2, No. 3, 4, 5, 7).

The Eastern (Amazonian) Lowland: in this wet area many native avocado trees could be found around the village of Rio Negro. In this eastern lowland, the avocado population is completely different from the one in the western lowland: the leaves are narrow (more or less like leaves of the Mexican race), the fruit is small, and has a thick skin, the seed is relatively large, the taste is good (watery in the west), but there is very little flesh to eat. None of the trees has an anise odor like the 'Nacionales1 up in the mountains. Of the three trees that we sampled (Table 2), the most typical to the region, according to the local people, is the one from Rio Negro. The one from Santa Inis had better quality, with smaller seeds. The seed form differs from the typical forms known for the three avocado races, and is like a cone.

Table 1. Avocado material collected in Ecuador in 1977 and 1987 by A. Ben-Ya'acov and R.J. Knight.

	Name	Year	Site	Form	Where found
1.	General Francisco Robles	1977	Quito	Scion	Miami, Bet Dagan
2.	Proteco	1977	Quito	Scion	Miami
3.	Reina Victoria	1977	Quito	Scion	Miami, Bet Dagan
4.	Fuerte Popenoe (1937)	1977	Quito	Scion	Miami
5.	14371 (Popenoe)	1977	Perucho	Scion	Miami, Bet Dagan
6.	Guayabamba (Nacionales)	1977	Guaya	Scion	Miami
7.	Guayabamba seedling	1977	Guaya	Seed	Bet Dagan
8.	Apakia I	1977	Chota	Seed	Bet Dagan
9.	Apakia II	1977	Chota	Seed	Bet Dagan
10.	Apakia III	1987	Chota	Seed	Bet Dagan
11.	Apakia IV	1987	Chota	Seed	Bet Dagan
12.	Apakia V	1987	Chota	Seed	Bet Dagan
13.	Apakia VI	1987	Chota	Seed	Bet Dagan
14.	Guatemalteco I	1977	Chota	Seed	Bet Dagan
15.	Maskaria I	1977	Chota	Seed	Bet Dagan
16.	Maskaria II	1977	Chota	Seed	Bet Dagan
17.	Banos	1977	Banos	Seed	Bet Dagan
18.	Perucho	1987	Perucho	Scion	Bet Dagan

The large variation in avocado types (and *Persea* species) in Ecuador, including unique endemic types, should be a subject for further investigation. The relationship between these types and the known types from Mexico and Central America is still an open question.

Costa Rica. In Costa Rica, the avocado (*P. americana*) and Yas (*P. schiedeana*) are well distributed around the country. Along the Pacific and Atlantic coastal areas of Costa Rica large populations of the West Indian race were found. These populations, although of high variability, do not differ from similar populations in Mexico and Central America. We decided to collect only a few special types, either seedless or with very small seeds.

Most of the avocado types of Costa Rica, from sea level up to the mountainous area, could not be defined as belonging to any one specific race. The fruits are round, oval or pyriform, and the seed is typical to the Guatemalan race, but the fruit skin is thin to medium, and thus closer to the West Indian race. We visited dozens of trees and came to the conclusion that they are intermediate types between these two races. Trees of this intermediate type were sampled. Very old trees and trees resistant to either dry or wet conditions were sampled. We could not find any representative of the Mexican race.

Table 2: Material collected in Ecuador in February, 1990 (*Persea americana* only)

	Name	Form	Type	Site/Comments
1.	Guayambamba II	Scion	'Nacionales'	Guayambamba; huge, strong tree
2.	Guayambamba III	Three seeds	'Nacionales'	Guayambamba; relatively big fruit
3.	Molestina	Scion	Pacific coast	Granja Molestina, near Quevedo
4.	Buena Fe	Scion	Pacific coast	Buena Fe Native
5.	Naranjito	Scion	West Indian	Navanjito, Guayaquil, from young seedlings growing near a large tree
6.	Urdesa (LM)	Scion	Pacific Coast	Urdesa, the city of Guayaquil
7.	Urdesa (LM.S)	Seed	Pacific Coast	Same tree (as no. 6)
8.	Rio Negro	Scion	Amazonian	Rio Negro, from seedlings of the native trees of this region
9.	Santo Inis	Scion	Probably Amazonian, but better fruit	Santa Inis near Rio Negro
10.	Rio Verde	Scion	Amazonian	Rio Verde near the road from a very healthy tree.

Under completely wild conditions we found an old Guatemalan type called by the people 'Nubichena', which could refer to *P. nubigena.* The fruit is round and typical of many Guatemalans with a very thick skin of 4 to 5 mm and very woody. The twigs and the fruit are covered with a corky layer.

In the mountainous areas of Costa Rica, many 'Yas' trees both old and young ones were found. The 'Yas' (or 'Jas') is the local name for *P. schiedeana*. The species is well distributed in most avocado countries, but has different local names in each country. In Costa Rica, people consider it a possible rootstock for avocado.

Many commercial cultivars were found in Costa Rica, among which 'Fujikawa' looks interesting.

Our impression is that Costa Rica has still a big and variable source of avocado germplasm which should be studied thoroughly.

Honduras. Root-rot is the number one problem of avocado cultivation in Honduras, as the country has heavy rains and in many cases the drainage is not the best. Fruit is therefore expensive and there are only a few commercial orchards in the country.

According to Lucille Kopp, the following *Persea* species should be found in Honduras: *P. americana* (vars. *americana* and *nubigena*), *P. schiedeana*, *P. vesticula* and *P. donnell-smithii*. According to W. Popenoe, wild avocado with an anise smell could be found. On our visit we concentrated on two groups: *P. americana* and *P. schiedeana.*

The Atlantic Coast: in this region we covered the area between La Ceiba and Tela. Entering the Sierra from the village of San Antonio (not far from La Ceiba), we found a population of *P. schiedeana*, although the forest is rapidly disappearing. People cut down many trees, even in the National Park area. *P. schiedeana* in Honduras has a few different names such as Chucte, Zucte, etc. We shall use the most common name - Zucte.

The Zucte at San Antonio Ariba (also called Buene Vista) has a very small fruit; later on, we learned that such a small fruit with no eating value is called 'Zucte de Mico". The people cut down the trees in order to grow corn, etc.

Out of the mountain area, many West Indian avocados could be found, representing very high variability. They can not be considered native trees, but their characteristics should be studied.

Some very old Guatemalan trees could be found as well at sea level. We wondered if they are the 'Aguacate de Anis', described by Popenoe as being hard-shelled. They have a pungent odor but not really of anise.

The Ocotepeque region: through San Pedro Sula we crossed the country from the Atlantic Coast to Santa Rosa de Copan, and from there south to Belen. The main item to be found in this region is the Zucte, mostly trees with big edible fruits, but also some with small poor fruit, considered as Zucte de Mico. People claim that some of the most primitive Zucte de Mico trees have round fruit, but we did not see such fruits. In our opinion, the large variability found in the *P. schiedeana*, both in Honduras and in other countries, and its close relationship to avocado, justify wide collection and study of this species.

We found in this region also one or two 'Aguacate de Mico' trees, with very small hard-shelled fruit.

Colombia and Guatemala. These two very interesting countries from the point of view of avocado germplasm were included in this study, but we were able to make only a very short visit during this period and we plan a longer one in the future. Meanwhile, a background study was done for both countries.

Discussion and Conclusions

The study described in this article, as well as in others in this volume, is now in its second year, and hence it is too early for any final conclusions to be drawn. From the surveys made in Mexico and the Latin American countries, we can state the following:

1. The eradication of the avocado and its relatives is proceeding rapidly, probably even faster than we could imagine previously, and faster than that of the other members of the same plant societies.
2. Primitive wild avocados and wild avocado relatives were found in some of the countries: this is the last chance to save them.
3. For the avocado itself, the accurate identification of the three races is possible only in Mexico and Guatemala. In Costa Rica and Honduras, it was almost impossible to find the Mexican race and Guatemalan trees were very rare. However, an intermediate type between the Guatemalan and the West Indian is very well distributed. The close relationship between these two races was found not only by the RFLP test, but also in the field.
4. The finding of a very primitive big Guatemalan in the highlands of Costa Rica is in contradiction to the idea that this race developed from *P. nubigena* and/or *P. steyermarkii*, and/or some other sources.
5. *Persea schiedeana* was found to be distributed throughout the avocado's lands of origin. It has its own great variability, which should be studied. Beside having edible fruit, it is graftable with the avocado and seems to be the only species that can be considered as material for the improvement of the avocado.
6. In addition to the field and laboratory studies, a germplasm bank was established, of which two plots are in Mexico and one in Israel. The composition of these plots is still a subject for further discussion, as one never has enough room for his collections. In the meantime, the horticultural value of these accessions is being investigated.

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