Ecology and cropping of cherimoya (*Annona cherimola* Mill.) in Latin America. New data from Ecuador

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Ecology and cropping of cherimoya (*Annona cherimola* Mill.) in Latin America. New data from Ecuador.

Abstract — Introduction. Cherimoya is one of the so-called *Lost Crops of the Incas* that has come to the world from the Andean heights. **Centre of origin and present distribution**. From its centre of origin, situated in or near Loja province in southern Ecuador, cherimoya is now cultivated in South America in an area going from Chili up to Mexico and California, in New Zealand, Australia, Thailand, Indonesia and South Africa. In Europe, Spain is an important producer that serves the European market. **Ecology and limiting production factors**. Recent research data gathered from wild cherimoya stands in Ecuador presented here refine the ecologic and edaphic ranges mentioned in literature. Wild cherimoyas occur in areas situated within a limited mean average annual temperature range (18–21 °C). Mean annual precipitation ranges 650–1250 mm. Soils are sandy loam, loam and sandy clay loam and stoniness can reach up to 50 %. Soil depth also varies a lot. Average values for the upper 25 cm show soils with pH ranging 5–6.5; organic matter content ranging 1–5 %; cation exchange capacity with an average value of 22 cmol(+)·kg^{-1} soil, soil potassium and phosphorous contents of 37 µg·L^{-1} and 73 µg·L^{-1}, respectively. **Cultivars and selection**. Data on local biodiversity also show the wild accessions to have a broad range of characteristics making them suitable candidates to be used in breeding programmes. The data presented here should allow would-be growers in subtropical countries to make a better choice of cropping environment and location. © Éditions scientifiques et médicales Elsevier SAS

Ecuador / *Annona cherimola* / forest resources / production factors / agronomic characters / production possibilities / economic resources

Écologie et culture du chérimolier (*Annona cherimola* Mill.) en Amérique latine. Nouvelles données obtenues en Équateur.

Résumé — Introduction. Le chérimolier est l'un des prétendus « fruitiers perdus des Incas » qui a été diffusé dans le monde à partir des hauteurs andines. **Centre d'origine et distribution actuelle**. Parti de son centre d'origine, situé près de Loja au sud de l'Équateur, le chérimolier est maintenant cultivé en Amérique du Sud (du Chili jusqu'au Mexique et à la Californie), en Nouvelle-Zélande, en Australie, en Thaïlande, en Indonésie et en Afrique du Sud. En Europe, l'Espagne est un producteur important pour le marché européen. **Écologie et facteurs limitant la production**. Des données récentes, issues de l'observation de chérimoliers sauvages en Equateur, ont permis de préciser les caractéristiques écologiques et édaphiques mentionnées dans la littérature. Les chérimoliers sauvages produisent dans des régions à températures annuelles moyennes limitées (18–21 °C), recevant des précipitations annuelles moyennes de 650 à 1 250 mm. Les sols sont constitués de terreau sableux, de terre grasse ou de terre glaise sableuse ; ils peuvent contenir jusqu'à 50 % de pierres. La profondeur de sol convenant au chérimolier varie également beaucoup. La couche supérieure de 25 cm présente un pH allant de 5 à 6,5, un taux de matière organique de 1 à 5 %, une capacité d'échange cationique de 22 cmol(+)·kg^{-1} en moyenne, des teneurs en potassium et phosphore de 37 µg·L^{-1} et 73 µg·L^{-1}, respectivement. **Cultivars et sélection**. L'observation de la biodiversité locale montre aussi que les chérimoliers sauvages présentent une large gamme de caractéristiques permettant d'envisager leur utilisation en amélioration variétale. Les données présentées devraient permettre aux cultivateurs potentiels des pays subtropicaux de mieux choisir l'environnement et la localisation des parcelles destinées à la culture de l'espèce. © Éditions scientifiques et médicales Elsevier SAS

Équateur / *Annona cherimola* / ressource forestière / facteur de production / caractère agronomique / possibilité de production / ressource économique

1. introduction

Cherimoya (*Annona cherimola* Mill.), custard apple (although this vernacular name usually refers to *A. squamosa*, it is used for *A. cherimola* in the UK and Commonwealth), chirimoya or chirimolla is one of the so-called *Lost Crops of the Incas* (terminology courtesy of Noel Vietmeyer [1]) that has come to the world from the Andean heights. These crops were not truly lost as they were and are well-known to the indigenous populations in the Andes. They were and are, however, lost to the mainstream of international science and to the consumers at large. In the context of Latin America as a whole and Ecuador more specifically, cherimoya has a future and enough potential to become a subtropical fruit crop for both resource-poor farmers and the commercial sector with international market outlets. Or, in the words of George et al. [2]: "The cherimoya (*A. cherimola* Mill.), sugar apple (*A. squamosa* L.) and custard apple (*Annona* hybrids) have the potential to become major horticultural crops"; or with Sanewski [3]: "On a world basis, the cherimoya is the most important species", ideas which are confirmed by Rasai et al. [4] who consider the abovementioned species together with the hybrid atemoya (*A. cherimola* × *A. squamosa*) to be major commercial species.

To become more commercially attractive, research will have to develop new varieties which appeal more to the average consumer, whereas production should be extended into suitable areas for its cultivation. The present article tries to (re)define the agro-ecological zones where cherimoya can be grown, and characterizes a number of wild accessions found in the centre of origin.

2. centre of origin and present distribution

Cherimoya's centre of origin lies in an area covering southern Ecuador–northern Peru, with the province of Loja (Ecuador), and Vilcabamba, the so-called sacred valley of Ecuador [5], probably being the primary centre of biodiversity (*annex 1*). The latter valley still contains wild stands of cherimoya, even though Farré Massip and Hermoso González [6] consider the area to be too dry and too warm for optimal fruit production.

Wild plants occur in the somewhat cooler to drier Andean valleys in the area, where they can form dense forested stands. Cherimoya had already moved into southern Mexico, central America and the northern part of South America in pre-Colombian times [7], when it was first sighted by the *conquistadores* coming to the continent in the 16th century. Not before the 18th century, however, were cherimoya seeds taken from the southern and central American continent into Spain and Portugal and, from there, further into the Mediterranean area into countries such as Italy and later on Egypt and Palestina, and, still later, throughout the world into areas with a similar ecology as in the centre of origin.

Nowadays, in South America, cherimoya is considered to be an important crop for Chili, where it is grown on approximately 1,000 ha, with production directed at both national and international markets, i.e., USA, Japan and a number of Latin American countries [8]. Production is situated in zones considered climatically adequate for cherimoya cultivation, and there is a tendency to develop high density production systems in order to make better and more intensive use of soil resources in a context of limited suitable land availability [9].

The fruit is also commercially produced, albeit often on a limited scale, in Peru, Ecuador, Colombia, Bolivia, Argentina, Brazil and Mexico [3]. In the latter country, it is found semi-cultivated in backyard gardens situated in the states of Morelos, Estado de México, Jalisco, Chiapas, Puebla, Guanajuato, Michoacan, Hidalgo and Veracruz, which have a subtropical climate. Cultivation is typically concentrated between 1,400 and 2,000 masl. Commercial cherimoya cultivation using regional selections and some commercial varieties has only recently started in Michoacan and

Annex 1.

The origins of *Annona cherimola*

Most early chroniclers agreed about the Andean region, and more specifically the Loja region, as being the centre of origin of cherimoya trees, even though some of them advanced central America as the cherimoya's centre of origin. In an ethnogeographical study done by Estrella [37], Cobo, an early Spanish chronicler, is indeed cited to state cherimoya to be a 'new' fruit for the Andean region, but Farré Massip and Hermoso Gonzalez [38] explain this confusion by stating that some early chroniclers may have confused the cherimoya with other *Annonaceae* (*A. reticulata* or *A. squamosa*) which indeed have a central American origin. In support of this hypothesis, Popenoe [33] argued that the common name which the fruit bears, even in Mexico, is of Quichua origin – it means cold seed. Moreover, terra cotta vases modelled from cherimoya fruits have repeatedly been dug up from prehistoric graves in Peru, showing their longstanding history in the area. Pittmann [24] suggests that, very early on, humans and maybe some animals distributed cherimoya seeds into south Mexico and central America where they became established as relatively wild plants.

León Fuentes [39] argues that the biological evidence for the exact location of the centre of origin of the species is difficult to define and will probably remain dubious as *Annonaceae* species tend to naturalise easily; he hereby refers to what happened to *A. squamosa* in India. Recent studies with molecular markers, cited by Hermoso González et al. [30], would suggest the possibility of Mesoamerica being a second centre of origin. Popenoe [40] presented it as being native to the Loja valley were it grows in the wild forming dense forest stands. Guzman [20] stated that the cherimoya probably originates from the forest of the Interandean slopes in the Marañón river basin, covering north Peru and south Ecuador, at elevations ranging 1500–2200 m above sea level (masl). Following these authors, most contemporary scientists now consider the temperate, dry Interandean valleys of southern Ecuador and northern Peru as being the centre of origin of the cherimoya [1–3, 41–44].

In this context, there is little doubt that Loja province, southern Ecuador, is situated in an important centre of biodiversity of this Andean fruit species, and may even coincide with its centre of origin, as might be derived from the fact that a number of toponyms in Loja province are constructed around the word *masa* which was shown by historian Inca Garcilaso de la Vega as early as 1609 to be the old Quichua name for the cherimoya fruit, meaning white.

Morelos. The produce enters the local markets, whereas there are some efforts to have the fruits exported to Japan [10]. The introduction in Brazil seems to be of a very recent date with the cropped area covering a limited surface [11]. Colombia's commercial cherimoya sector is confined to the Antioquia Department (1,500–1,900 masl) and still in its teens (Sanchez, personal communication). Official statistics, used in taxation, show that, in 1998, total commercialised cherimoya production amounted to some 8,000 kg (Coppens, personal communication).

Cherimoyas are also cultivated in southern California, where cherimoya cropping started in 1871, in Carpinteria. Approximately some 120 ha are cultivated, producing 1,000 t yearly (2 million lb.) for consumption in the USA and abroad [12]. Florida is also mentioned as a cropping area, but this probably refers mistakingly to atemoya, *A. cherimola* × *A. squamosa* [13].

Outside the new continent, it is cultivated in Central and South Africa (on an experimental basis in the latter country, in the Nelspruit area situated in the eastern regions of the Republic of South Africa), Thailand and Indonesia, Australia and New Zealand (where it has developed as a crop in the nineties [14] using cultivars introduced from Ecuador, Chile and Peru [15]), and especially in the Mediterranean [1, 3, 16].

Figure 1.
Cherimoya plants in a homegarden in Loja province (Ecuador).

Figure 2.
Cherimoya fruits in a homegarden in Loja province (Ecuador).

Senanayake (personal communication) states that cherimoya was introduced into Sri Lanka some 120 years ago. It is not clear, however, where the plant material used came from. Nowadays, it is grown as a homegarden tree at 1,200 masl in the Uva and Kothmale valleys. The produce enters the local and national trade, but is not exported.

Worldwide, Spain is the most important commercial cherimoya producer, with New Zealand having become an important contender of late [4], especially because, in the latter country, the fruit can be produced in conditions with little danger of freeze damage [15]. After its introduction into Spain during the 18th century, the crop became quickly established in the southern part of the country, more specifically in Andalusia. During the 20th century, the crop developed in the coastal zones of Malaga and Granada. The Almuñecar valley, near Malaga, might well contain the biggest concentration of commercially grown cherimoya trees in the world; at present, some 950 ha are being cultivated. In the Rio Verde valley (Jete – Otivar) there are a further 1,800 ha under cherimoya. All in all, there are at present some 3,600 ha of cherimoya trees in Spain, which yielded some 20,000 t of fruit in 1991 [3]: in the Malaga and Granada areas, total surface is 3,500 ha (up from 106 ha in 1956), whereas the rest of peninsular Spain has some 100 ha more. Furthermore, there are 50 ha in Madeira, 15 ha in the Azores, and 4 ha in the Canaries.

However, most of the cherimoyas that are consumed and/or sold, often on a local, regional or national scale, come from plants growing in homegardens or backyards (*figures 1, 2*) and from plants that grow in the wild. This is especially true for South America, its area of origin. In all these instances, plants are basically left unattended, without special management or use of inputs. The cherimoya is thus an important backyard crop in Ecuador, Colombia, Venezuela, Bolivia and Peru. True cherimoya estates only occur in Chili, Spain, and USA.

3. ecology and limiting production factors

Recent results of a field survey realised in 1995 [17] confirmed and refined earlier findings. The survey determined the growing conditions in 20 wild cherimoya stands combining results from 52 soil samples measuring from every soil: horizon texture (method of Boyoucus), pH (H_2O), phosphorous (method of Olsen) and potassium content at the Soil Laboratory of the Universidad Nacional de Loja (southern Ecuador). For every parameter, the analytical results for the different horizons were recalculated to an average value using weight factors decreasing with depth following Sys et al. [18]. Climatological data for a number of climatic stations (period 1971–1986) were obtained at the Universidad Nacional de Loja [19] and *Programa de Desarrollo para la Regiõn Sur* [20]. Average monthly temperature, precipitation and relative humidity data were used.

The present study summarizes data from other scientists and compares them with the results of the edaphoclimatological survey executed in the centre of biodiversity by the authors.

3.1. climatic conditions

Earlier on, Guzman [21] concluded that temperature and availability of water are the limiting factors for plant growth and development. Later studies have confirmed that relatively dry and cool areas are optimal for cherimoya. It resents excessive dry heat, and is thus not suited for (semi-)arid conditions. Farré Massip and Hermoso González [6] state that an annual precipitation of more than 600 mm, and preferably over 1,000 mm, is necessary in order for (wild) cherimoyas to grow and produce (e.g., in the absence of irrigation). Annual precipitation cannot exceed 1,700 mm due to the phytopathological problems these high levels may cause.

Mean annual temperature can vary between 18–22 °C [22] (figures confirmed for Colombia by Sanchez, personal communication) with a minimum of 13 °C for optimal fruit quality and 16 °C for optimal tree development. Maximum temperatures may not exceed 30 °C, because this causes problems with pollination [9]. According to some sources, cherimoyas can withstand low temperatures of –5 °C. Short periods of 12–15 d with temperatures ranging –2 to +4 °C, or longer periods with minimum temperatures between 6 and 10 °C are harmful, however. It would seem that younger plants tolerate frost better than older specimens [23] although this point is argued [5]. Pittman [24] states that temperature limitations can vary with the cultivar. If cherimoyas do not receive enough chilling, the trees will go dormant slowly and experience delayed foliation. The amount of chilling needed is estimated to be between 50 and 100 h [5]. Sudden changes in temperature are problematic during pollination, but seem to positively influence fruit maturation [25].

George et al. [2] emphasize the importance of relative humidity during flowering with 70 % being the lower boundary, under which flowers will easily abscise and stigmas desiccate, and 95 % being the upper limit where sugar secretions produced by the stigmas become too diluted.

Our own measurements have shown wild cherimoyas to occur in areas situated within a limited mean average annual temperature range (18–21 °C; *figure 3*) with mean minimum temperatures ranging 10–12 °C, and mean maximum temperatures ranging 26.5–30 °C. Mean annual precipitation figures for the same areas range 650–1,250 mm (*figure 4*). Because the latter values also occur in areas where cherimoyas are not known to occur, we conclude that temperature is a more limiting, and thus more important, factor than precipitation in defining optimal environments for cherimoya cultivation [17, 26].

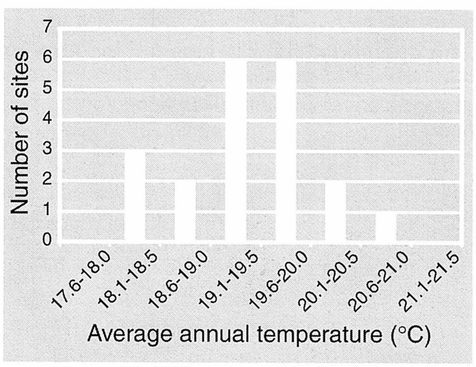

Figure 3.
Mean average annual temperature in different sites where wild cherimoyas occur [17].

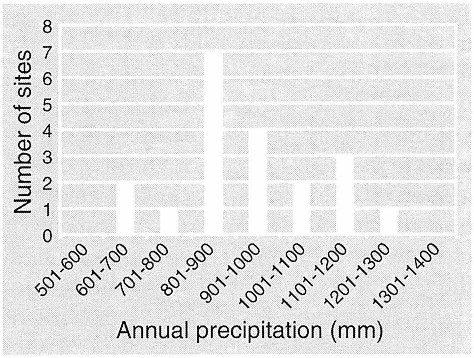

Figure 4.
Annual precipitation in different sites where wild cherimoyas occur [17].

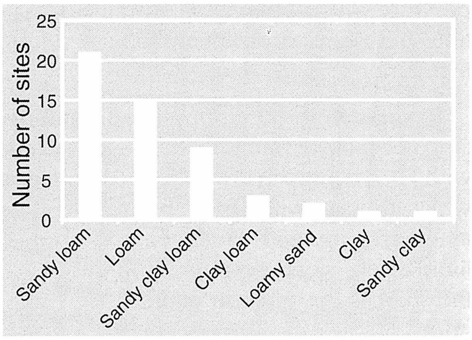

Figure 5.
Soil texture in different sites where wild cherimoyas occur [17].

3.2. soil characteristics

From literature, it is clear that soil texture for cherimoya can vary a lot. However, well-drained sandy to sandy loamy soils seem to be preferred [2, 3, 9]. According to Martínez Quesada [27], pH varies between 6.5 and 7.6, and organic material content between 1.7 and 2.7 %. Ruiz Camacho [25] states that cherimoya prefers semi-arid soil (and environment) conditions, and thrives well on marginal soils that have sand-clay texture, and 'sufficient' organic matter content (no figure given), and with pH between 6.5 and 7.6.

Our own data, based on recalculated textures from 52 sampling points in wild cherimoya stands in southern Ecuador (Loja province), show soils with a relatively high sand percentage to predominate. The most frequent textures encountered under wild cherimoya stands are sandy loam, loam and sandy clay loam (*figure 5*). Stoniness can be very high, in some places reaching values of up to 50 %. Soil depth also varies a lot. Shallow soils (10–15 cm) can support cherimoya, but most sites seem to have soils of 50 cm or deeper.

With regard to pH, organic matter content, and Cation Exchange Capacity (CEC), average values for the upper 25 cm were taken. Most soils were shown to be slightly acidic with pH varying between 5 and 6.5. The content of organic matter is moderate with values ranging 1–5 % with an average value of 3.6 %. CEC is also moderate with an average value of 22 cmol(+)·kg^{-1} soil. Soil potassium and phosphorous contents average values of 37 µg·L^{-1} and 73 µg·L^{-1}, respectively [17, 26].

3.3. conclusion on cherimoya ecology

In the wild, cherimoya is known to occur in dry and basically relatively cool areas. There is, however, some dissent amongst authors as to the optimal growing conditions for the crop. Based on literature data and our own findings through field visits of wild cherimoya stands in Ecuador, climatic (*table I*) and edaphic (*table II*) suitability

Table I.
Climate characteristics and the ensuing suitability classes for *Annona cherimola,* based on authors' data.

Suitability class	Annual precipitation (mm)	Annual temperature (°C)		Altitude (m)	Relative humidity (%)
Good	> 800	20.4–17.4		1,600–2,000	< 80
Moderate	600–800	22.7–20.4	for	2,000–2,400	> 80
		or 17.4–13.3	for	1,200–1,600	
Not suited	< 600	> 22.7	for	> 2,400	–
		or < 13.3	for	< 1,20	

Table II.
Soil characteristics and the ensuing suitability classes for *Annona cherimola,* based on authors' data.

Suitability class	Texture	Soil depth (cm)	CEC[1] (cmol(+)·kg^{-1} soil)	Organic matter (%)
Good	Loam, sandy loam, sandy clay loam	> 30	> 18	< 3
Moderate	Clay loam, silt loam, sandy clay, silty clay, loamy sand, silt, sand, silty clay loam	< 30	< 18	> 3
Not suited	Coarse sand, massive clay	–	–	–

[1] CEC = Cation Exchange Capacity.

classes have been defined [17]. Through data coming from production areas elsewhere in the world, we can indeed conclude that cherimoya only thrives well in a limited range of subtropical to mildly temperate climates, and tolerates light frosts. It is worth attempting growing in sunny, south-facing (in the northern hemisphere), nearly frost-free locations, and cherimoya may survive in protected locations (such as the Almuñecar valley in Andalusia).

4. cultivars and wild relatives to be used in selection

Loja province, situated in a centre of biodiversity for *A. cherimola*, gave the unique opportunity to study fruit variability in wild or loosily managed cherimoya trees. Between January 1996 and March 1998, 32 sites in Loja province were visited [28] and 137 accessions were collected and characteristics of size (using caliper, absolute error 1 mm), weight (using balance, ± 0.1 g), colour (using Royal Horticultural Society Colour chart), skin type (using botanical forms defined by Schroeder [29]), seed number and soluble solids (using a 0–32 °Brix refractometer, ± 0.2 °Brix) were measured for each collected fruit and averaged for every tree.

4.1. literature review

Right from the beginning, farmers and later researchers have been selecting cherimoya cultivars for better fruit quality, yield, pest and disease resistance, harvest period and rusticity. Most cherimoya plantations have been established using grafted material so that the most popular cultivars have more or less fixed properties. In the USA, selection has been going on for some 100 years now, and thus, the choice in cultivars is somewhat richer than in other production areas.

The most popular cultivars are now: 'Fino de Jete', which occupies some 95 % of the Spanish cherimoya area [30]; 'Bays', 'Booth', and 'White' (United States and Australia [31]) which cover some 60 % of total production in California [12] but comprise also 'Big Sister', 'Carmela', 'Chaffey', 'Ecuador', 'El Bumpo' (which has a soft practically edible skin), 'Honeyhart', 'Knight', 'Libby', 'McPherson', 'Nata', 'Ott', 'Pierce', 'Sabor', and 'Whaley' [5], 'Reretai' and 'Burton's Favourite' in New Zealand; 'Bronceada' and 'Concha Lisa' in Chile [32], and 'Cumbe' in Peru [22]. In Colombia, only 'Rio Negro' has more or less well-defined characteristics.

Gardiazabal [8] states that the varieties of Chilean origin have some favourable characteristics, such as loose seeds, and good post-harvest storage, but, on the other hand, they have a low sugar content and are late-maturing in the principal cultivation areas.

The genetic resource basis out of which most of the cultivars listed here have been developed is rather limited, however, and would need to be expanded in order to broaden the spectre of cultivars offered, and to increase the species' resilience against pests and diseases. At present, the Andalusian research station *La Mayora* has a germplasm collection of 274 accessions mostly from Peru (Farré Massip, personal communication).

Ripe fruits are sweet and juicy. They have a high sugar content (20–22 %), and are low in acids (1 %) [1, 24]. The white flesh is melting, subacid and very fragrant. Its aroma reminds one of a mixture of strawberry, banana and pineapple. Popenoe [33] refers to it as *"the pearl of the Andes* and *queen of subtropical fruits"*; Twain (in [33]) calls it *"deliciousness itself"*; Haenke (in [24]), *"the masterpiece of nature"*; whereas Markham (in [27]) ascertains that *"its taste surpasses that of every other fruit"*. Fruits belong to five botanical forms defined by Schroeder [29]: mamillate (bot. f. *mammillata*), tuberculate (*tuberculata*), umbonate (*umbonata*), fingerprint (*impresa*; contains 'Fino de Jete') or smooth (*laevis*). These types differ according to skin type and, to some degree, concomitant taste. It should be pointed out however that there exists a lot of confusion at this level, with "skin type" and "fruit type" being used by different authors in different ways.

Cherimoya fruit is consumed fresh, when fully ripe. It is primarily a dessert fruit of which the fleshy, white to creamy mesocarp of each carpel is consumed by cutting the fruit in half or quartering it, and eating the content with a spoon. The seeds are inedible. Flavour of the ripe fruit is improved by chilling just prior to eating; ripe fruits can be frozen and eaten like ice cream. Cherimoya fruit is also used for making ice cream, milkshakes or sorbets. It is processed into yoghurt, flan, fruit juice and wine [1].

Shelf life is limited [34]. Skin and flesh are easily bruised and subsequently rot sets in quickly [2]. The same authors prescribe fungicide treatments to protect fruits from rot. In the case of unripe fruits, shelf life can be increased up to 2 weeks (at temperatures ranging 15–16 °C and at high relative humidity). 'Fino de Jete' fruits have been shown to retain their quality after having been kept at 8 °C for 12 d. Palma et al. (in Bydekerke [23]) showed 'Concha Lisa' fruits could be kept for reasonably long periods at 10 °C and 5 % O_2.

Shelf life and transport over long distances have improved following new cultivar development, improved cropping technique and modern transport. When packed in sponge foam, and kept at cool temperatures (9–12 °C) in special cardboard or wooden boxes, cherimoyas can be sold in the international market [35]. Traditionally grown cherimoya fruits are basically consumed on a local and regional scale, near their centre of production. Though unusual in appearance, cherimoyas are readily accepted by western tastes and have become a favourite tropical fruit. Commercial plantations normally produce for (export) markets. As an example, New Zealand exports significant amounts to Japanese and American markets [14], whereas the Andalusian fruits are exported to European markets.

4.2. research results

In Ecuador and the other cherimoya-producing countries in the area, such as Bolivia, Colombia or Peru, subsistence farmers at best propagate cherimoya trees from seeds, so that no real true to type cultivars are found there, resulting in very heterogenous yields. In and near the centre of diversity, fruits are picked from trees growing in the wild. This results in a genetic variability which could be used in breeding programmes for new cultivar development. Germplasm collection and characterization, as undertaken by Scheldeman and Van Damme [28, 36] in southern Ecuador, might broaden the scope for new cultivar development in Ecuador and, by extrapolation, South America and the other major cropping areas.

Selection criteria used have usually concentrated on fruit characteristics (*table III*),

Table III.
Cherimoya selection criteria used in Spain, Australia and final criteria proposed by the authors for the species selection [6, 32].

Criteria origin	Skin type	Fruit weight (g)	Flesh recovery (% pulp)	Seed (%)	Seed index[1]	Soluble solids (°Brix)
Spain	Smooth or impressed	> 300	–	–	< 6	> 20
Australia	Smooth	300–600	> 60	3–5	< 10	18–20
Authors	Smooth or impressed	> 300	> 60	< 5	< 6	> 20

[1] Seed index = number of seeds per 100 g of fruit.

but should also take into account pest resistance, especially against fruit flies (*table IV*). Research data show that the average wild cherimoya tree in Loja province produces fruits with a weight of 400 g, a seed index of 13 with 8 % seeds on a seed weight/total weight basis, and 22 °Brix of soluble solids. However, variability is such that it should be possible to breed for bigger (*figure 6*), sweeter (*figure 7*), and smoother fruits from the resource base present in the area.

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Table IV.
Characteristics of the 15 cherimoya best morphotypes selected in the collection realized in Loja province (Ecuador) [28, 36].

Code	Region	Parish	No. fruits characterized	Skin type	Fruit weight (g)	Pulp (%)	Seed (%)	Seed index[1]	Soluble solids	Fruit fly infection
CEC1	Paltas	Sta Cecilia	5	Unknown	804.1	65.5	4.4	5.6	20.0	0
CEC6	Paltas	Sta Cecilia	4	Tuberculate	752.5	67.5	3.1	5.6	20.0	50.0
GUA1	Espindola	Guarinja	4	Impressed	926.0	72.9	4.9	6.1	22.9	25
GUA3	Espindola	Jimbura	3	Smooth	587.7	67.1	4.2	4.5	26.5	66.6
GUA4	Espindola	Guarinja	3	Smooth	436.7	67.8	1.7	5.1	22.1	33.3
GUA5	Espindola	Guarinja	5	Smooth	771.9	63.3	4.7	5.3	22.7	40.0
JUA3	Calvas	San Juan	4	Impressed	746.1	62.7	5.7	6.9	22.6	25
JUA4	Calvas	San Juan	5	Umbonate	769.6	58.2	6.7	7.1	20.4	0
JUA5	Calvas	San Juan	3	Impressed	444.7	66.4	3.4	5.8	20.4	66.6
LAU1	Paltas	Lauro Guerrero	5	Smooth	640.4	71.8	4.9	6.4	27.5	0
MAR1	Loja	Marcobamba	3	Smooth	431.6	69.4	5.2	5.7	26.3	66.6
MAR3	Loja	Marcobamba	4	Impressed	456.2	65.7	4.3	6.1	24.1	0
NAM11	Gonzanmá	Nambacola	5	Smooth	628.4	64.6	4.3	4.5	21.5	80
TIO1	Espindola	Sta Terisita	4	Impressed	560.6	79.6	2.8	3.9	20.6	0
YUR1	Quilanga	Quilanga	4	Smooth	679.3	68.4	3.1	5.8	20.8	0

[1] Seed index = number of seeds per 100 g of fruit.

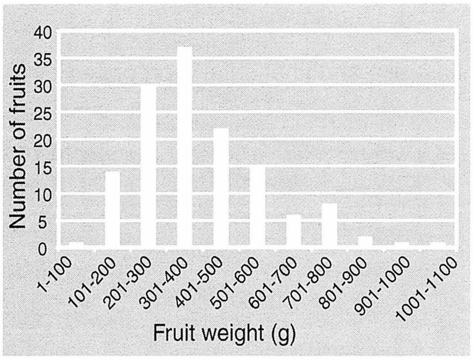

Figure 6.
Histogram of fruit weights for 137 accessions collected between January 1996 and March 1998, in 32 sites in Loja province (Ecuador) [28].

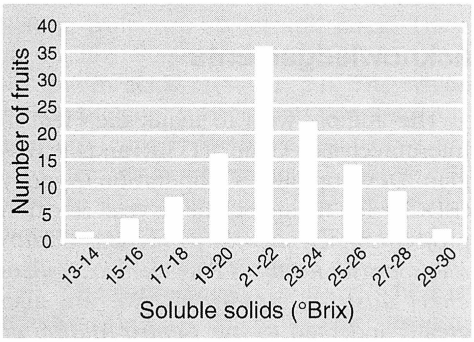

Figure 7.
Histogram of soluble solids for 137 accessions collected between January 1996 and March 1998, in 32 sites in Loja province (Ecuador) [36].

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Ecología y cultivo de la chirimoya (*Annona cherimola* Mill.) en América Latina. Nuevos datos de Ecuador.

Resumen — Introducción. Chirimoya (*Annona cherimola* Mill.) es uno de los dichos "Cultivos Perdidos de los Incas" lo cual ha sido distribuido en el mundo desde las alturas de los Andes. **Centro de origen y distribución actual**. Desde su centro de origen, situado en o cerca de la provincia de Loja en el Sur del Ecuador, la chirimoya se encuentra actualmente cultivada en América del Sur en un área extendido desde Chile hasta México y California, en Nueva Zelanda, Australia, Tailandia, Indonesia y África del Sur. En Europa, España es un productor importante para el mercado europeo. **Ecología y factores limitando la producción**. Datos de investigaciones recientes, obtenidos del estudio de árboles silvestres en Ecuador, han permitido precisar las características ecológicas y edáficas mencionadas en la literatura. Chirimoyos silvestres se encuentran en una zona con temperaturas anuales promedias limitadas (18–21 °C), recibiendo precipitaciones anuales promedias de 650–1250 mm. Suelos son de textura franco, franco-arenoso y franco-arcilloso-arenoso con pedregosidad hasta 50 %. La profundidad del suelo conveniente para el chirimoyo también es muy variable. La capa superficial de 25 cm presenta un pH variando entre 5 y 6,5; un contenido de materia orgánica de 1 al 5 %, una Capacidad de Intercambio Catiónico (CIC) promedia de 22 cmol(+)·kg^{-1} suelo, y contenidos de potasio y fósforo de 37 µg·L^{-1} y 73 µg·L^{-1} respectivamente. **Cultivares y selección**. Datos de la biodiversidad también muestran que las accesiones silvestres tienen un amplio rango de características, permitiendo concebir su utilización en programas de mejoramiento. Los datos presentados deben permitir a los cultivadores potenciales en países subtropicales escoger de una manera más correcta el ambiente y la localización de las parcelas destinadas al cultivo de la chirimoya.

Ecuador / *Annona cherimola* / recursos forestales / factores de producción / características agronómicas / producción potencial / recursos económicos