Annona muricata L.
Monograph

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Introduction:

Annona is a genus of tropical fruit trees that belong to the Annonaceae family, which consists of more than 119 different species. Soursop, or *Annona muricata* L (as it is known scientifically) was distributed throughout the tropics after the arrival of the Spanish in the Americas. Nowadays, the plant itself and other species of the family are widespread in the West Indies, North and South America, lowlands of Africa, Pacific Islands and Southeast Asia. The soursop fruit and other parts of the tree are considered to be underutilized, information on the composition, nutritional value, medicinal uses and toxicology of the plant is limited and scattered. Guanabana fruit grows on a small, flowering, evergreen tree that can grow to approximately 30 feet. The fruit itself is dark green and prickly, with a white inside that contains pulp and a core of black seeds (Ntbg, 2015). The pulp is edible and commonly used to make natural fruit juices and smoothies, although it is also eaten by itself. Its taste is described to be a mixture between pineapple and mango . Guanabana seeds are black and inedible, they can even cause poisoning if ingested. It is a very perishable fruit, with a shelf life of 5 days after being harvested at physiological maturity (Morton, 1987).

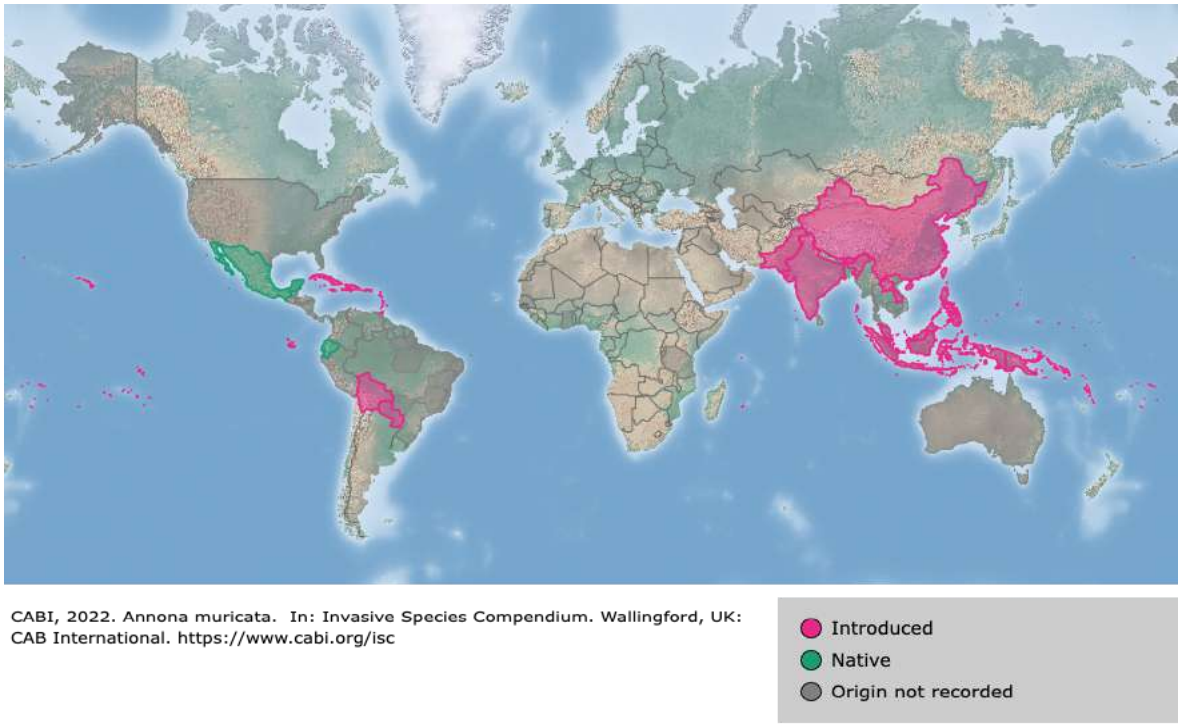
The information on this monograph is divided into 4 different chapters: Ecology, this chapter will include some general information about the plant and its characteristics. Biology, this chapter will cover the germination process of the plant and some genetic characteristics. Propagation and management, this chapter will cover the management of the plant and how it is prepared for commercialization. Finally, Importance will cover the general uses of the plant and its role on the market.

Chapter 1: Ecology

1.1 Origin:

Guanabana, also known as *Annona muricata* L, is a fruit that belongs to the Annonaceae family. The fruit originated in the Antilles (Caribbean) but it is mostly seen in South America and other tropical and subtropical regions, including India, Australia, and the Philippines (Padmanabhan & Paliyath, 2016), Figure 1 below.

Figure 1- Origins of *Annona muricata* L



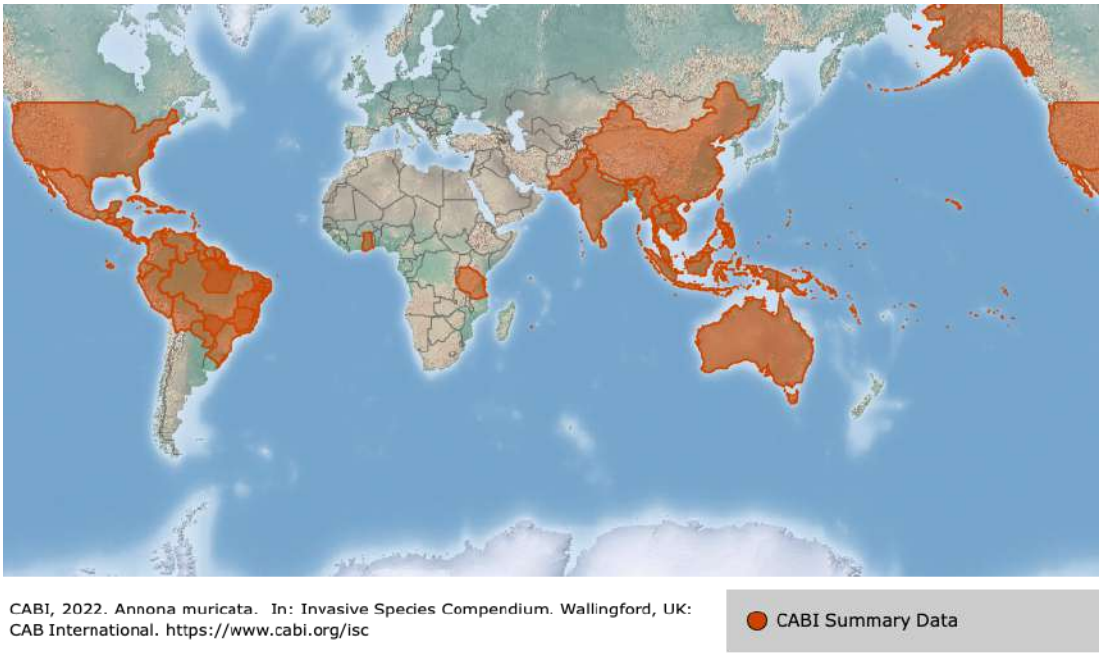
Source: Cabi, 2022.

1.2 Ecology:

Annona muricata L survives in the humid tropical and subtropical lowlands (Wagner & Lawrence, 2014.). Because of this, it is common on the West Coast and the southern states in North America, in all Central America, and all countries of South America except Argentina, Uruguay, and Chile. Soursop is also grown in Southern and

Southeastern Asia (in countries of the Malay Archipelago), Australia, Ghana, and Tanzania (USDA Plants Database, 2014) (Figure 2, below). It has become naturalized in thickets, pastures, and along roads, but is commonly grown in home gardens and found in rural garden areas on volcanic and raised limestone islands. Trees are not found on atolls and are able to withstand little frost (Larranaga & Hormaza, 2015).

Figure 2- Current distribution (2020) of *Annona muricata* L



Source:Cabi, 2022

Biophysical limits:

-Soursop plants need to grow in an area with a mean annual temperature of 25-30 degrees and about 1000 mm of rainfall annually. (Morton & J.F 1987)

1.3 Taxonomy:

Domain: Eukaryota

Kingdom: Plantae

Phylum: Spermatophyta

Subphylum: Angiospermae

Class: Dicotyledonae

Order: Annonales

Family: Annonaceae

Genus: Annona

Species: *Annona muricata* L

(ITIS, 2014.)

1.3.1 Related species:

The Guanabana belongs to the Custard Apple family (Annonaceae). The family also includes the cherimoya (*A. cherimola*) , custard apple (A reticulata) and sugar apple (*A. muricata* L). Soursop is a distant cousin of the North American Pawpaw. (Britannica, 2021)

Figure 3 -Types of Annona

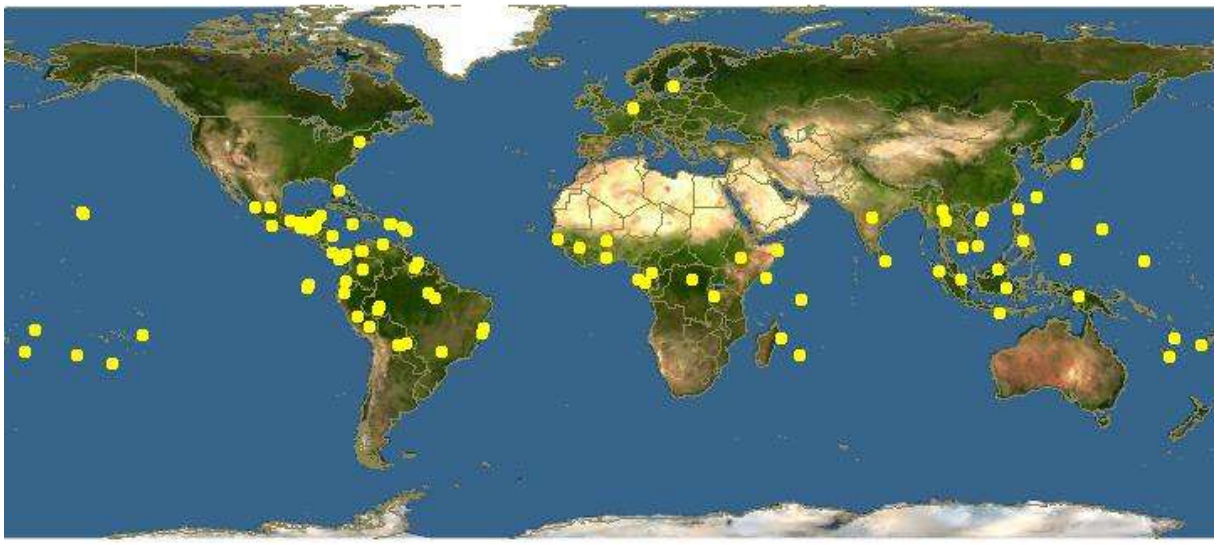
1.4 Affinity:

The Annoncaceae, also known as custard apples, are a family of plants made up of more than 2000 species (Padmanabhan & Paliyath, 2016). About 900 of these species are neotropical, 450 afrotropical and the others are Indomalayan. Some of these species are used as ingredients while others have medicinal properties . The most desired characteristic of soursop is having no fiber or reduced fiber in the flesh of the fruit. The species on this family can be trees, shrubs, and woody climbers (Tamokou, & Kuete, 2017). Some of the most commonly used cultivars are: “Morada” (from Brazil), “Cuban Fibreless” (Australia), “Sirsak ratu” (Java) and Bennett (from the US, mainly found in Florida). Other edible fruits on the Annona genus include: Atemoya, Biriba, Cherimoya, Ilama, Custard Apple, Mountain Soursop, Pond Apple, etc.

1.5 Fossil record:

The oldest common ancestor of the Annonaceae family is the Futabanthus (a genus) that originated in Japan in the late Cretaceous period (Raven & Axelord, 1974). Other old fossil records come from seeds and pollen from the Maastrichtian period of Nigeria and Colombia, this shows the fruit originates from the Gondwana supercontinent, despite other records indicating it’s japanese origin (Takahashi, 2008).

Figure 4- ***Annona muricata*** **L fossil record**



Source: Cabi, 2022

1.6 Distribution:

The countries that produce the most guanabana in the world are Brazil, Colombia and Ecuador. In the major producers of guanabana the fruit registers very high consumption rates, however there is a small part that is exported to other countries like the US and Germany (Cardozo et al 2016). Recently, countries in the European Union have shown interest in guanabana grown in South America, this is because Europe doesn't have the ideal conditions for the plant.

Figure 5 - Major producing countries (highlighted in red)

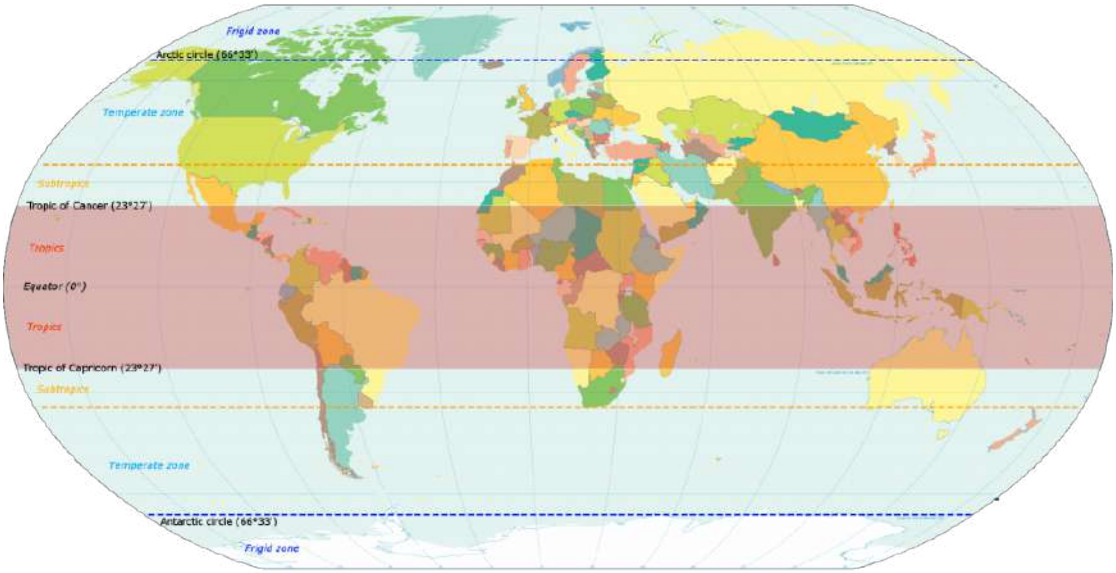


Figure 6 - Ranking of major producing countries

Rank	Country	Share in Export Value 2020	Export Value 2020, USD	1-Year Growth in Export Value 2019-2020	3-Year Growth in Export Value 2017-2020	Weekly Domestic Price Change	Monthly Domestic Price Change 2022-01	Harvesting Seasonality
1	Canada	11.87%	$417.95M	+13.37%	+57.1%			-
2	Thailand	7.29%	$256.70M	+16.78%	+180.94%			-
3	Peru	6.25%	$220.07M	+29.52%	+86.67%			-
4	Poland	6.25%	$219.87M	+4.63%	+26.83%			-
5	Chile	6.17%	$217.07M	+15.03%	+29.68%			-
6	United States	4.85%	$170.88M	+2.38%	+7.7%			-
7	Netherlands	3.82%	$134.40M	-1.2%	+12.75%			-
8	Mexico	3.8%	$133.91M	+9.02%	+54.15%	+1.87%		-
9	Serbia	3.42%	$120.57M	+23.34%	+10.5%			-
10	Malaysia	3.4%	$119.61M	+46.48%	+444.93%			-

1.7 Elevation and Climate:

The guanabana tree can grow at sea level and up to elevations of 1.500 meters. It can only grow in tropical climates (Popenoe, 2009).

1.8 Temperature:

Soursop is adapted to areas of high humidity and warm winters. Any temperature below 41 degrees fahrenheit will cause damage to the leaves and small branches and temperatures below 37 degrees fahrenheit can be fatal for the plant, as it makes the fruit dry (Lestari & Sofiah, 2015).

1.9 Soil:

Guanabana trees can tolerate a wide range of soils, however it needs a spot with good water draining and soft, sandy soil. Seeds need to be planted 20 cm deep into the soil. Guanabana trees are very tropical and can tolerate a wide range of soils, however they grow best when planted in well drained, sandy soil with a Ph ranging from 5-6.5. The tree does not tolerate cold or strong sustained winds (Love, 2011).

1.10 Relation with insects:

1.10.1 Beneficial:

The hard seeds of Annonaceae fruits, which are often uninjured by the process of mastication and digestion, are proven to be planted accidentally by horses, hogs and birds. Some fruit trees and shrubs (including Annonaceae ones) bear the favorite food of birds like the Columba leucocephala and Columba corensis (Amadeo, 1888).

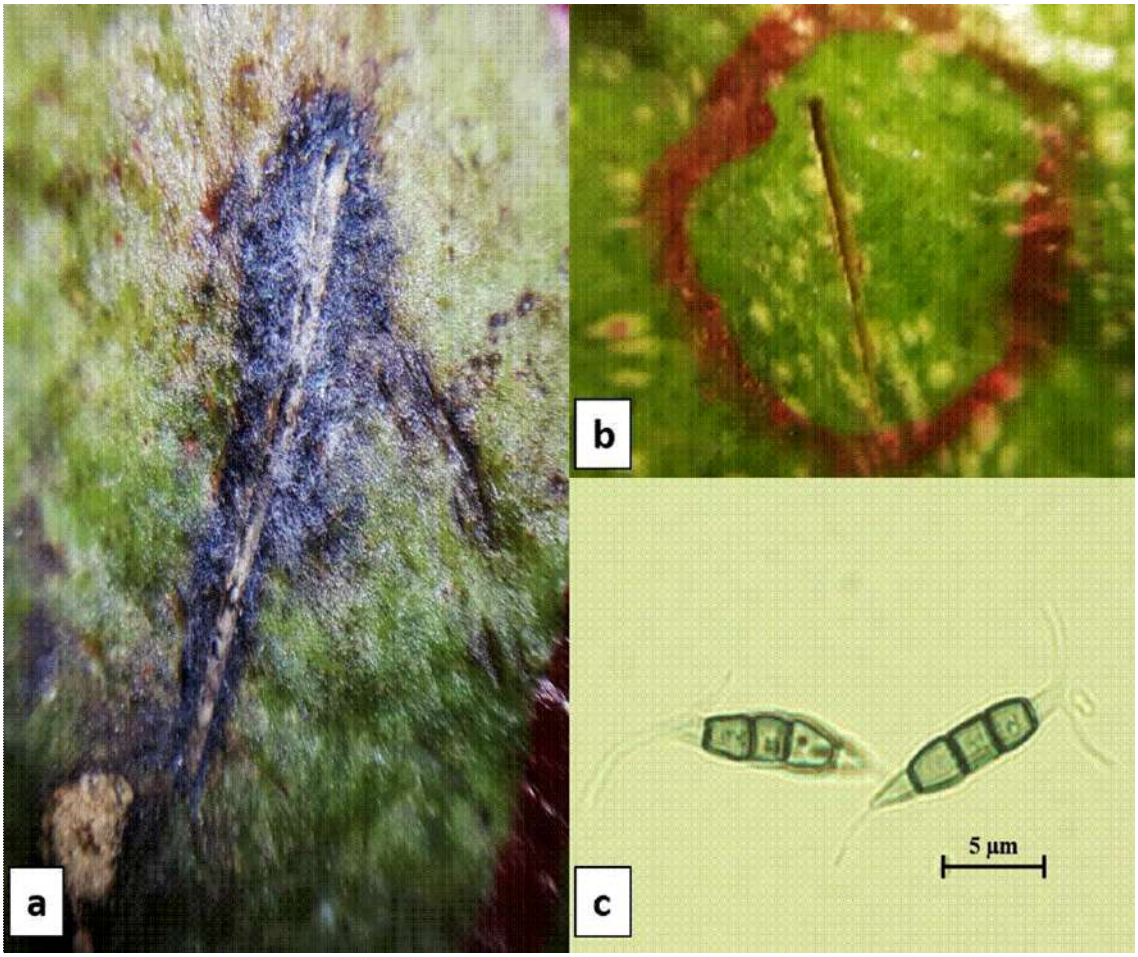
1.10.2 Non-beneficial:

One of the main pests of Soursop is the *Maconellicoccus hirsutus*, an exotic species native to Southeast Asia but found in almost every Tropical and semi-Tropical region of the world (Cabi, 2021). This pest spreads through infested plant material and from 1995-2008 caused economic losses in the Caribbean region equal to 18.3 million dollars (Fao, 2013). In Mexico, this pest caused the production of soursop to decrease 26%. (2006-2009). The M. hirsutus affects all phenological stages of a crop, its presence also favors the development of sooty mold on the plant (Ogbuehi, 2019).

As many as 199 insects infest fruits of the Annonaceae. In Mexico, these species have been recorded: including a fruit borer (Lepidoptera: Pyralidae), Stenoma spp., (Lepidoptera: Oecophoridae), Neosilba spp. (Diptera: Lonchaeidae) in fruits: Acanthocephala femorata Fab. (Hemiptera: Coreidae), Euphoria leucographa (Coleoptera:

Melolonthidae), Collembola, Aphis gossypii (Hemiptera: Aphididae) in flowers, as well as parasitoids and predators (Cabi, 2021).

Figure 7 - Soursop diseases (A: Dry rot, B: control soursop, C: conidia fungus)



Source: SciELO.org

Chapter 2: Biology

Biology:

“A small, upright evergreen which cannot stand frost. It may be grown only in the warmest parts of Florida or in greenhouses. The leaves are dark green and glossy. The fruit is 6-9", yellow green in color, with white flesh. The pulp is excellent for making drinks and sherbets and, though slightly sour-acid, can be eaten out-of-hand” (UCONN, 2022).

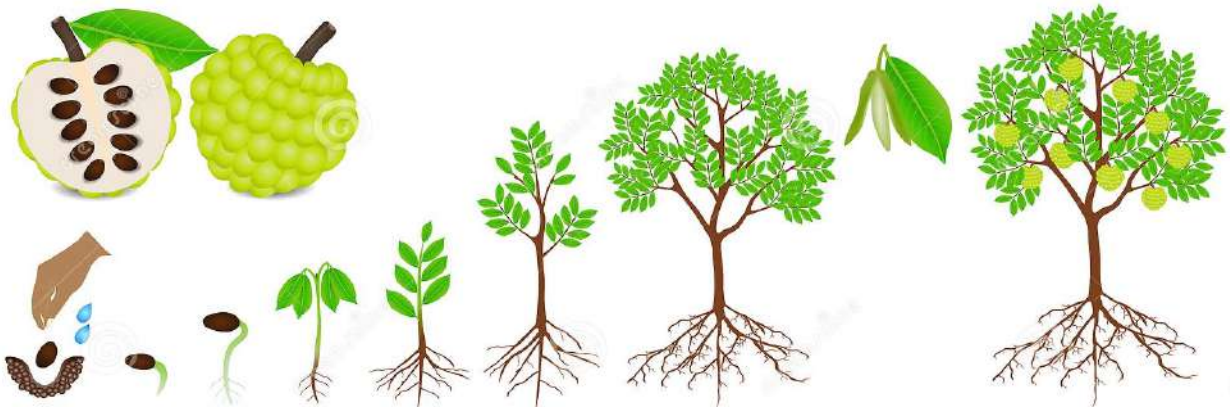
2.1 Chromosomes:

1n = 8; 2n = 14 (P. Goldblatt & D. E. Johnson, 1979)

2.2 Life cycle and Phenology:

When planted the seeds will germinate within 15-30 days. According to the Purdue University College of Agriculture, a soursop tree will reach a mature height of 15 to 20 feet after 6 years and will bear fruit in 3-5 years. The tree produces two dozen fruits in its second year, these must be allowed to ripen for 4-5 days after harvesting (Love & Paul, 2011).

Figure 8 - Growth cycle of a soursop plant



A: Sprout, B: Seedling, end of the plant’s germination, happens within 15-30 days of the seed being planted C: Vegetative, D: Budding, E: Flowering, happens 3 to 5 years from the seedling stage of the plant.

Source: Dreamstime stock images

2.3 Deciduousness:

The tree produces fruit year round but the peak comes during summer and early autumn, sometimes with another peak in early spring. It is not tolerant to extreme cold and sustained winds, but it is versatile when it comes to soil (Fao.org, 2021).

2.4 Reproduction and pollination:

Soursop can be propagated by seed, grafting and layering. They must be pollinated manually to ensure a good harvest. Although the flowers are hermaphroditic they cannot self-fertilize, the stigma (female part) is receptive before the stamens (male parts) reach maturity. The previous feature in addition to low attractiveness to insects result in poor pollination. To pollinate a Soursop tree, one must put a little pollen on the stigma of the flower. "The flowers are protandrous, the pollen is shed as the outer petals open towards the evening. The inner petals open much later and only very slightly, admitting small insects attracted by the fragrance of the flowers" (Cabi.com). Nitidulid beetles (*Carpophilus* & *Uroporus* spp.) are important pollinators of the soursop as they cross pollinate the flowers, however most of the ovules are not fertilized at all in this process (Gerbaud et al, 2013).

2.5 Anthesis:

Annona trees generally require 27-35 days for the full development of their flowers (from initiation to anthesis) (Tripathi et al, 2014).

Figure 9 - Soursop flowers

Source: Wikipedia,2015

Chapter 3: Propagation and management

3.1 Propagation:

To grow soursop the seeds are taken directly from the fruit, soaked in warm water overnight and then taken and planted directly on the soil (½ inch deep). If the soil is kept damp they should grow in two weeks to a month (Gardeningtips.com, 2020).

3.2 Grafting:

Soursop has been successfully grafted onto cherimoya rootstock (with a 73.3% to 83.3% percent success). Soursop can also be grafted onto any rootstock species with a 33% success rate (Heenkenda et al, 2009).

3.3 Management:

Field sanitization: Good field sanitization is very important to control wasps (animals that deposit their larvae into the fruit for them to grow). Picking up any decayed fruit or seeds and burning them guarantees that wasps stay away. If burning is not possible, leave the waste in a clear bag in the sun for about two weeks before disposing or composting (Raymond T, 2013).

Bagging: The fruits must be left in either a mesh or plastic bag. When bagging fruits, they must be 2.5-5.0 mm long. Before putting the fruit in bags, you must assure they have no aphids, whiteflies, mealybugs or scales on them. When plastic bags are used, they must have small holes for drainage (Raymond, 2013).

3.4 Harvesting and storage:

The harvest of soursop happens when the color of the fruit lightens and changes to a yellowish green color, with segment margins becoming smooth and less noticeable. It normally takes 4 or 5 days for the fruit to fully ripen after it's picked, this is when the skin yields to slight pressure. Studies conducted in the island of Hawaii have shown that the optimum stage for eating is 5 to 6 days after harvest (Anuragi, et al 2016).

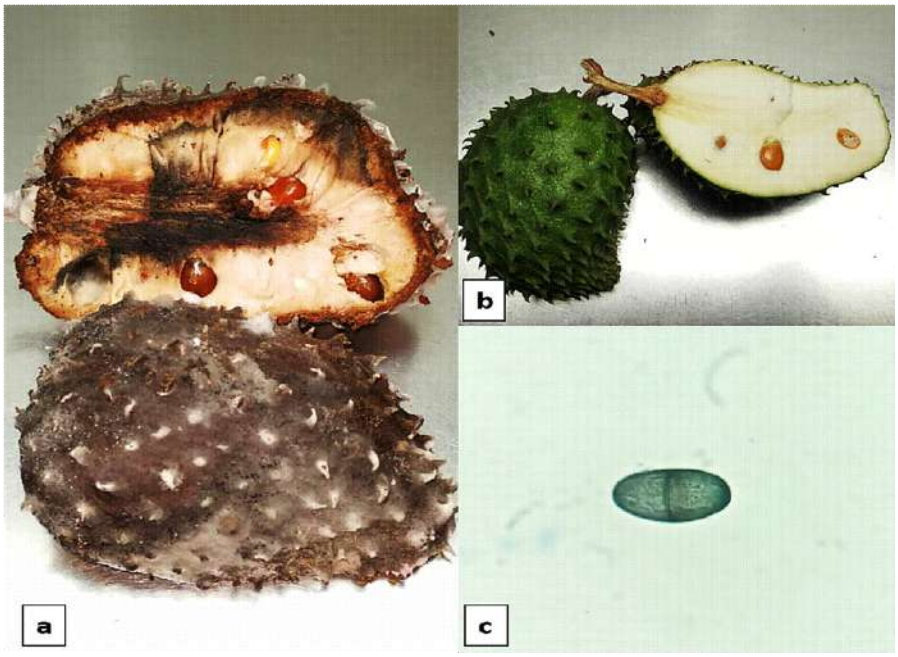
Figure 10 - Ripe and Unripe Soursop

Source: Alkalineveganlounge, 2021

3.5 Pest and disease control:

Some common problems that soursop presents may include mealy bugs, root grubs, carpenter moth larva and scale insects. Commercial insecticides can only be used with precaution due to the possibility of them killing off beneficial insects during pollination. Homemade pesticides can be made with cup vegetable oil and water, which works to suffocate insects, insect larvae and eggs (Briz, 2014). There are numerous diseases that affect the growth and development of the soursop plant. Diseases that attack leaves or roots can cutt of the nutrient supply of the plant, these come in the form of fungal disease like root rot and pink disease. These fungus can be countered by spraying the tree with fungicides early in the season (Richardson, 2019).

Figure 11 - Rotting soursop



Source : Revista Biociencias Mexico, 2019

Chapter 4: Importance

4.1 Markets:

-According to statistics, the global guanabana market accounted for $152.03 million in 2019 and is expected to reach $390.07 million by 2027 (Marketsearch, 2019). Some key players in this market are: Amanaci Rohstoffe UG & Co.KG, Amelia Organic Products, Austrofood Cia Ltda, Flavorah FLV, Fructo AG, Goya Foods, Inc., Jumex Group, Now Health Group Inc and Sunshine Naturals (Marketsearch, 2019).

Major producers in North America include the US, Canada and Mexico. In Europe: Germany, France, Uk, Italy and Spain. In Asia: China, Japan, Korea, India. In South America: Brazil, Argentina and Colombia. In Oceania: Australia and New Zealand and in the Middle East and Africa: Saudi Arabia, UAE, Qatar and South Africa.

Figure 12 - Top importer and exporters of soursop (international market)

Source: Tridge, 2022

Figure 13 - Mexico Soursop market (local market)

Source: Tridge.com

4.2 Use and trade:

Processed or raw soursop is distributed through: Direct selling, Hypermarkets/Supermarkets and Independent Grocery Stores (Marketsearch, 2019). Soursop in these forms is used to make cosmetics and personal Care products, in the food processing industry, to make nutraceuticals/pharmaceuticals and for household consumption (Marketsearch, 2019).

4.3 Products:

“Soursop is the most suitable species of the genus Annona in terms of industrial potential and commercialization due to its agreeable aroma and taste” (Sanusi & Bakar, 2018). The fruit is extensively used in the food industry to make ice creams, candies, nectars, yogurts, syrups, sherbets, canning and to prepare beverages (Pinto et al, 2005). In

Brazil and Cuba, a drink is prepared by mixing soursop pulp with milk and sugar, in Puerto Rico it is common to mix these ingredients with water instead of milk (Badrie & Schauss, 2010).

Figure 14 - GOYA Soursop nectar, sold in countries located in Central America

Source: Latinfoodsmarket.com

Figure 15 - Soursop juice with milk

Source: Jamaicanrecipes.com

4.4 Medicinal properties:

Soursop plants possess high medicinal values, for example acetogenins from soursop exhibit anticancer properties, “although information about the plant part suitable to use for isolation of these secondary products is still unknown” (Pinto et al, 2005). “The only organization interested in the industrialization of secondary products so far is Rain Tree, United States. Furthermore, there is a success in using domestically prepared insecticide from extracts of wild soursop in Africa” (Pinto et al, 2005).

References

-Amadeo, A. J. (1888). “The Dispersion of Seeds and Plants.” *Nature*, *37*(962), 535–535. https://doi.org/10.1038/037535d0

-Anuragi, H., Dhaduk, H. L., Kumar, S., Dhruve, J. J., Parekh, M. J., & Sakure, A. A. (2016). Molecular diversity of Annona species and proximate fruit composition of selected genotypes. *3 Biotech*, *6*(2), 204. https://doi.org/10.1007/s13205-016-0520-9

-Badrie, N., & Schauss, A. G. (2010). Chapter 39 - Soursop (Annona muricata L.): Composition, Nutritional Value, Medicinal Uses, and Toxicology. In R. R. Watson & V. R. Preedy (Eds.), *Bioactive Foods in Promoting Health* (pp. 621–643). Academic Press. https://doi.org/10.1016/B978-0-12-374628-3.00039-6

-Cardozo, C. J., Villacorta Lozano, V., Yepes Betancur, D. P., Ciro Velásquez, H. J., & Cartagena Valenzuela, J. R. (2012). Physiological and Physico-Chemical Characterization of the Soursop Fruit (Annona muricata L. cv. Elita). *Revista Facultad Nacional de Agronomía Medellín*, *65*(1), 6477–6486.

-Ecosystems Research and Development Bureau Guyabano (Annona muricata Linnaeus) Vol. 26 Nos. 3, September-December 2014 Research Information Series on Ecosystems ERDB, College 4031, Laguna

-FAO. (1986). Food and Fruit Bearing Forest Species. No. 3: Examples from Latin America. Forestry Paper 44/3. Rome: FAO

-Gerbaud, P. (2013). *Soursop (Annona muricata L.)*. https://www.fruitrop.com/en/Articles-by-subject/Agronomy/2013/Soursop-Annona-muricata-L.

-*Goldblatt, P. and Johnson, D.E. (1979) Index to Plant Chromosome Numbers (IPCN). - References—Scientific Research Publishing*. (n.d.). Retrieved April 27, 2022, from https://www.scirp.org/(S(351jmbntvnsjt1aadkozje))/reference/referencespapers.aspx?referenceid=2004826

-Heenkenda, H. M. S., Gunathilaka, B. L., & Iswara, J. P. (2009). Rootstock-scion interactions of selected Annona species. *Journal of the National Science Foundation of Sri Lanka*, *37*(1), 71–75. https://doi.org/10.4038/jnsfsr.v37i1.460

-Hormaza, J., Carmona-Martín, E., Gonzalez-Padilla, I., Larranaga, N., Lora, J., Talavera, A., & Encina, C. (2015). *Annona/ spp. Atemoya, cherimoya, soursop and sugar apple.* (pp. 65–78). https://doi.org/10.1079/9781780648279.0065

-*ITIS - Report: Annona muricata*. (2014). https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=18098#null

-Love, Ken, et al. "Soursop." *Hawaii Tropical Fruit Growers*, CTAHR Dept. of Tropical Plant and Soil Sciences, 2011, **ctahr.hawaii.edu**.

-Lutchmedial, M., Ramlal, R., Badrie, N., & Chang-yen, I. (2004). Nutritional and sensory quality of stirred soursop (Annona muricata L.) yoghurt. *International Journal of Food Sciences and Nutrition*, *55*(5), 407–414. https://doi.org/10.1080/09637480400002800

-Morton, J. (1987). *Fruits of Warm Climates*. https://hort.purdue.edu/newcrop/morton/index.html

-Ogbuehi, H. C., & Onuh, M. O. (2019). Evaluation of soursop (Annona muricata L) leaf extract on the control of fleabeetles (Podagrica spp.) and yield of okra (Abelsmoschus esculentus L. Moench). *Journal of Agriculture and Food Sciences*, *17*(2), 21–33. https://doi.org/10.4314/jafs.v17i2.3

-Padmanabhan, P., & Paliyath, G. (2016). Annonaceous Fruits. In B. Caballero, P. M. Finglas, & F. Toldrá (Eds.), *Encyclopedia of Food and Health* (pp. 169–173). Academic Press. https://doi.org/10.1016/B978-0-12-384947-2.00031-3

-Pinto, A. C.de. Q., Cordeiro, M. C. R., de Andrade, S. R. M., Ferreira, F. R., Filgueiras, H. A.de. C., Alves, R. E., & Kinpara, D. I. (2005). Annona species. International Centre for Underutilized Crops. Southampton, UK: University of Southampton

-Popenoe, W. (1920). Manual of Tropical and Subtropical Fruits. New York: Hafner Press

-Raven, P. H., & Axelrod, D. I. (1974). Angiosperm Biogeography and Past Continental Movements. *Annals of the Missouri Botanical Garden*, *61*(3), 539–673. https://doi.org/10.2307/2395021

-Richardson, K. V. A. (2019). *GLADSTONE ROAD AGRICULTURAL CENTRE TECHNICAL BULLETIN NO. 5*. 2.

-Sanusi, S. B., & Abu Bakar, M. F. (2018). Soursop—Annona muricata. In S. Rodrigues, E. de Oliveira Silva, & E. S. de Brito (Eds.), *Exotic Fruits* (pp. 391–395). Academic Press. https://doi.org/10.1016/B978-0-12-803138-4.00053-8

-Takahashi, M., Friis, E. M., Uesugi, K., Suzuki, Y., & Crane, P. R. (2008). Floral Evidence of Annonaceae from the Late Cretaceous of Japan. *International Journal of Plant Sciences*. https://scholar.google.com/scholar_lookup?title=Floral+Evidence+of+Annonaceae+from+the+Late+Cretaceous+of+Japan&author=Takahashi%2C+Masamichi&publication_year=2008

-Tripathi, P. (2014). *(PDF) Sour Sop(Annona muricata) – An emerging fruit of future*. https://www.researchgate.net/publication/303802504_Sour_Sop_Annona_muricata_-_An_emerging_fruit_of_future

-Wagner, Herbst, & Lorence. (2014.). *Flora of the Hawaiian Islands*. Retrieved May 2, 2022, from https://naturalhistory2.si.edu/botany/hawaiianflora/

-Wagner, W., & Lorence, D. (2014). *Flora of the Marquesas Islands*.
https://naturalhistory2.si.edu/botany/marquesasflora/