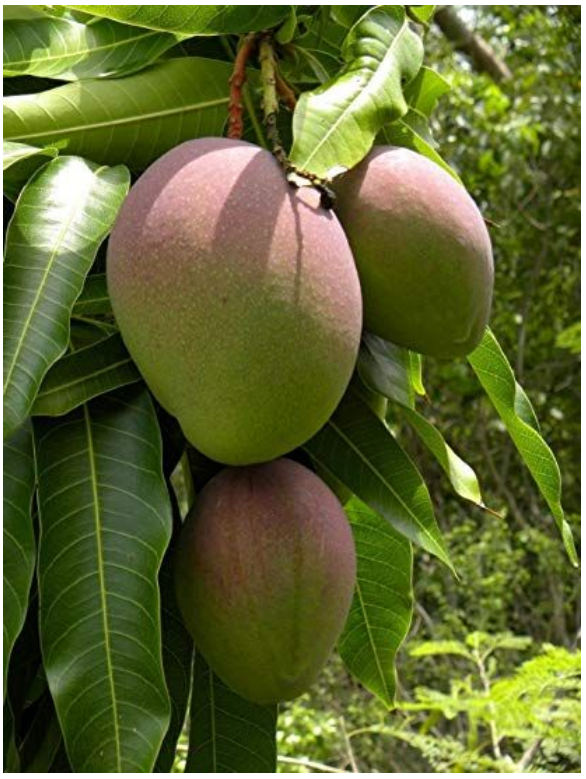
Mangifera indica L



Agricultural Science Monograph

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Index

Chapter 1: Importance

Mangifera indica L is a variety of the plant more commonly known as Mango. This monograph is dedicated to its in-depth research and investigation. It will address its ecology, biology, propagation, management,market and uses. The Ecology chapter will include affinities, origin, fossil records, present distribution and environmental factors. The Biology chapter will include chromosome complement, life cycle, phenology, reproductive biology, pollen, pollination, pollinators, fruit development and seed set. The Propagation and management chapter include natural regeneration, nursery propagation, planting and management. And finally the market and uses chapter will contain its global market and the found uses of this plant. *Mangifera indica* is a very well known fruit around the world, but what may not be known is that eating mangoes comes with enormous health benefits. It is important to be healthy and eating mangoes can definitely help, but this is not the only thing it brings to the table. Mango represents a substantial part of the fruit economy, estimated to be around 17 billion dollars and its plantation, cultivation and sales give jobs to millions of people worldwide. Remember, when you are eating mango it's not just a quick snack, but a much larger contribution to your health and the economy.

Chapter 2: Ecology

2.1 Distributional Context

2.1.1 Affinities

Commonly known as Mango, *Mangifera indica* L is made of the eukaryotic cell which means it has a nucleus and membrane-bound organelles (Bally, 2006) *M. indica* belongs to the Plantae kingdom, meaning it is a multicellular autotrophic organism that has cell walls composed of cellulose (Bally, 2006). Also, it belongs to the division of Magnoliophyta meaning it is an angiosperm that produces flowers and fruits (Bally, 2006). Pictured below are the flowers of *M. indica* (Figure 1). *Mangifera indica* is part of the Magnoliopsida class, which means the mango tree is a eudicot due to the presence of two cotyledons in the embryo and flowers with 4 or 5 petals (Bally, 2006). And its subclass is Rosidae due to it having elaborate flowers with as many stamens as petals (Bally, 2006). *Mangifera indica's* respective order is called Sapindales thanks to the mango tree compound leaves that alternate growth along the stem. (Bally, 2006). It belongs to the Anacardiaceae family, because it is found primarily in tropical regions. (Bally, 2006). Its genus is *Mangifera* because this organism is an evergreen tree with drupe-like fruit and is found in tropical areas (Bally, 2006). Finally *Mangifera indica* belongs in the *indica* species thanks to it being native to India and for it producing greenish to red drupes. (Bally, 2006)

Figure 1: Mangifera indica flowers and fruits just starting to develop (Queensland Government, n.d.).

Taxonomy of *Mangifera indica* (Rojas-Sandoval & Acevedo-Rodriguez, 2014)

- Domain: Eukaryota
- Kingdom: Plantae
- Division: Magnoliophyta
- Class: Magnoliopsida
- Subclass: Rosidae
- Order: Sapindales
- Family: Anacardiaceae
- Genus: *Mangifera*
- Species: *indica*
- Scientific Name: *Mangifera indica L*

2.1.2 Origin

Mangifera indica's native home is suggested to be in Eastern India, more specifically in the Indo- Burma region (*Mango Botany and Taxonomy*, 2006) Figure 2. *Mangifera indica* is native to Asia or the Malay archipelago, based on the multitude of varieties cultivated in those areas (*Mango Botany and Taxonomy*, 2006). Based on recent findings, the centre of origin of the genus Mangifera is now firmly established in Southeast Asia (*Mango Botany and Taxonomy*, 2006). However, the origin of Mangifera Indica has been a matter of speculation for many years, but a recent found of a leaf imprint found in Assam, India.. (*Mango Botany and Taxonomy*, 2006).

Figure 2: Map of Burma region where Mangifera Indica was originated from (Burma Regions Map | Regions Map of Burma | Burma Country Regions Map, n.d.)

2.1.3 Fossil records

The fossils left behind by *Mangifera indica* are pretty limited, but there is one of them in Assam, a state in India, which is a leaf impression of *M. penaranda,* which is a *Mangifera indica* subspecies (Mukherjee, 1972). This has led scientists to the conclusion that *Mangifera indica* appeared during the Quaternary period, (*Mango Botany and Taxonomy*, 2006).

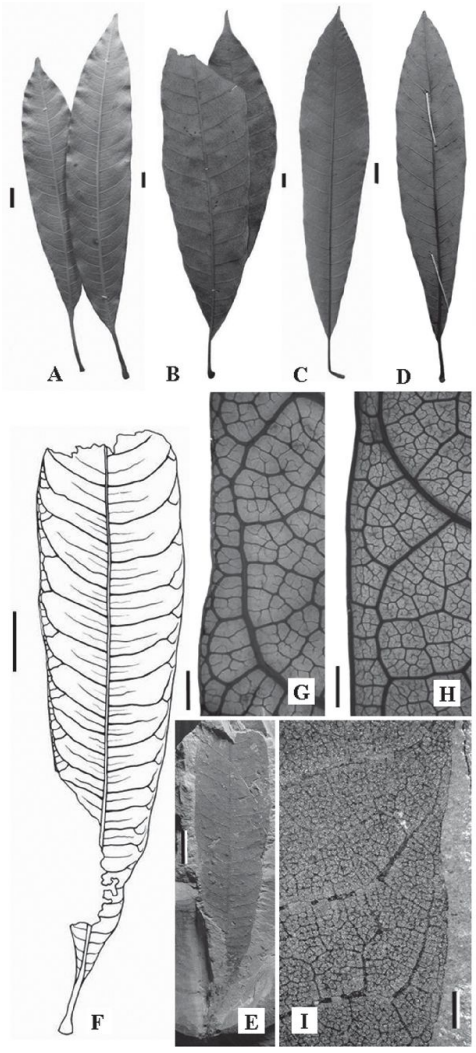


Figure 3: fossilized Mangifera Indica leaf. ("Figure abbreviations: BKF = Bangkok Forest Herbarium; MVP = marginal... | Download Scientific Diagram," n.d.)

2.1.4 Present distribution

The natural distribution of *M. indica* is in the Indo Malaysian region, specifically in India and Myanmar. It can also be found in the Assam-Chittagong hills, located in southeastern Bangladesh (Rojas-Sandoval & Acevedo-Rodriguez, 2014). *M. indica* has naturalized throughout the tropics and subtropical areas, thanks to the expansion of the human population. *Mangifera indica* contains hundreds of cultivars and is now a pan-tropical and even sub-tropical crop being cultivated in 113 countries according to the Food and Agriculture Organisation of the United Nations (2020) (Figure 3 below).

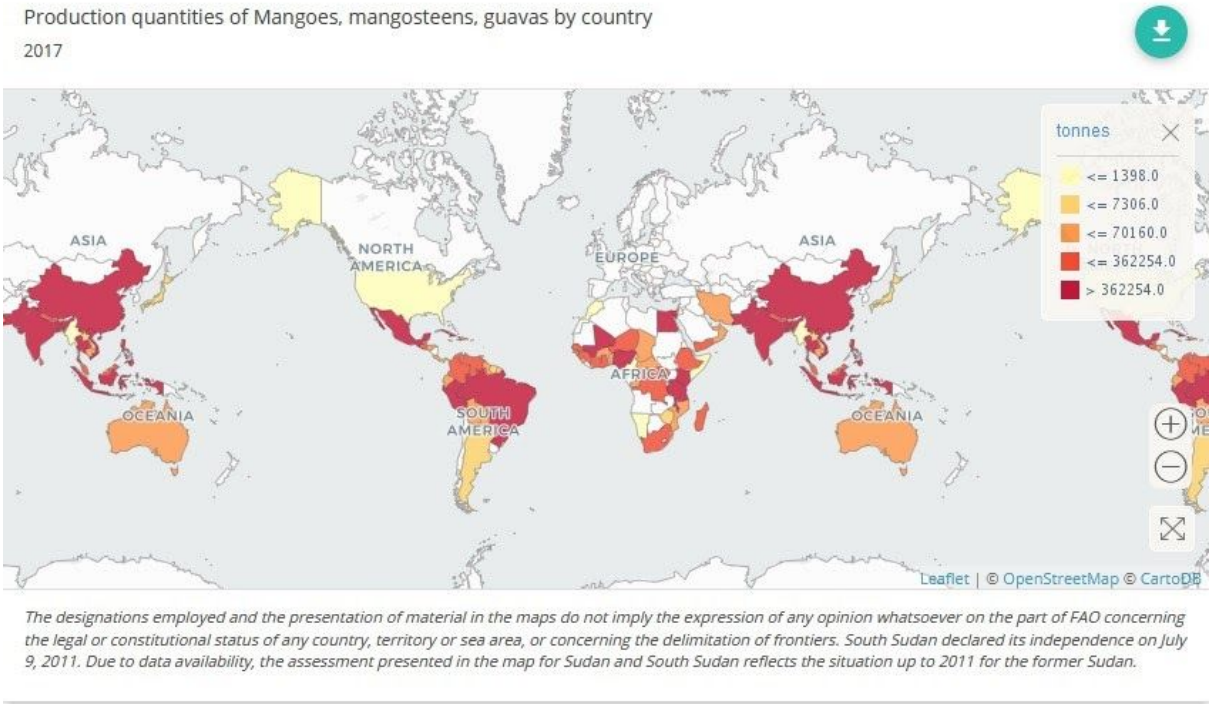


Figure 4: Map of the world showing the production quantities (FAOSTAT, 2019)

2.2 Environmental factors in the distribution

2.2.1 Elevation

Mangifera indica should be located around 600 meters above the sea level all the way up to 1200 meters above the sea level (L, 1996). This is to ensure a healthy development of the plant (L, 1996).

2.2.2 Climate

This species growth best ranges from the monsoon tropics to the frost-free subtropics, with a marked dry, or cool, season of at least three months to promote flowering (L, 1996.) *M. Indica* grows best in areas where annual temperature ranges 24 - 30 degrees celsius, even though it can tolerate 8 - 48 degrees celsius (L, 1996). This plant requires an annual rainfall in the range of 600 - 1500 mm of water but tolerates 300- 2,600m (L, 1996). While trees grow best in moderately dry climates, some cultivars can grow even in rainforest conditions (L, 1996).

2.2.3 Geology and soils

Mangifera Indica is not too picky over the soil it grows, not needing very fertile conditions, however very poor soil or shallows land will be unsuitable for the plant's growth (L, 1996). This makes the plant grow better in rich, well-drained soil (L, 1996).

2.2.3.1 pH of Soil

Mangifera Indica grows best in soils with a pH ranging 5.5-7-5, but can tolerate up to 4.3 acidity levels and 8.5 basic levels in the soil (L, 1996).

Chapter 3: Biology

3.1 Chromosome Complement

Studies have shown that varieties of *Mangifera indica* developed in Brazil have a chromosome complement that is a stable diploid with a number of 2n=40 (Pierozzi & Rossetto, 2011). However, there are some differences concerning chromosome size which were observed analyzing the varieties of *M. indica* Pierozzi & Rossetto, 2011). They displayed higher average chromosome length and ratio (Pierozzi & Rossetto, 2011). Figure 5 below shows mitotic chromosomes of *M.indica*, while table one shows the lengths of *M. indica* chromosomes.

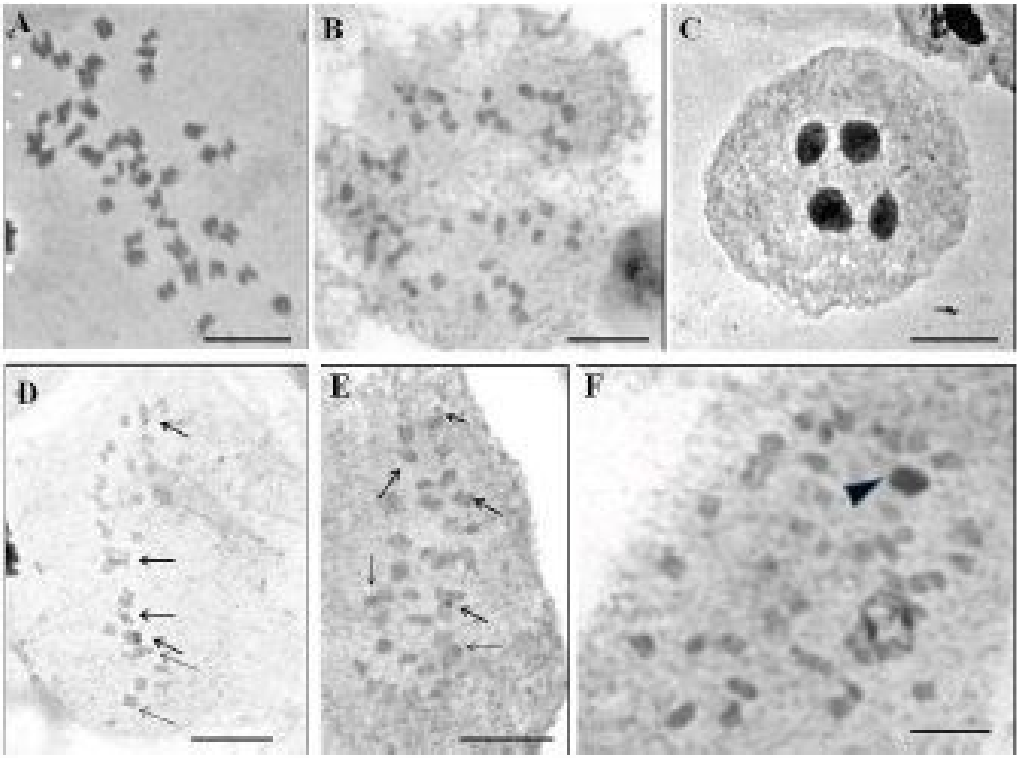


Figure 5: Mitotic chromosomes of M. indica from (Pierozzi & Rossetto, 2011).

We can see the chromosomes in figure 5 above, it shows how not all chromosomes are the same size.

Table 1: M. indica chromosomes lengths and averages from (Pierozzi & Rossetto, 2011)

TABLE 1 – Mean values with sd for total haploid chromosome length (THCL), average chromosome length (χchrom), the longest (L) and the shortest (S) chromosome length and the ratio of the longest to the shortest chromosome (L/S) for *M. indica* vars. 'Stahl' and 'IAC-140'

Var.	TCHL (µm)	L (µm)	S (µm)	χ crom	L/S
Stahl	28.08±2.45[a]	1.83±0.09[a]	1.00±0.08[a]	1.40±0.12[a]	1.76±0.21[a]
IAC 140	24.37±1.52[a]	1.81±0.15[a]	0.87±0.07[b]	1.22±0.08[a]	2.10±0.22[b]

Means followed by the same letter = differences were not significant at the level of 1% after F test.
Means followed by different letters = differences were significant at the level of 1% after F test.

In The work of Pierozzi and Rosetto we can observe that there are differences in the length of *Mangifera Indica's* chromosomes.

3.2 Life Cycle and Phenology

3.2.1 Life cycle

Mangifera indica originated as an Indian evergreen tree that has a perennial life cycle, meaning it can live and grow for several years. Some *Mangifera indica* trees are 300 years old and still producing fruit (Robie Benve, 2019). Below Figure 6 shows *Mangifera Indica's* life cycle, initiating with The seed which grows to be a small plant with about five petals per branch. Then it grows bigger up to becoming a large tree, flowers start appearing and out of the flowers is where the mango fruit grows and resides .

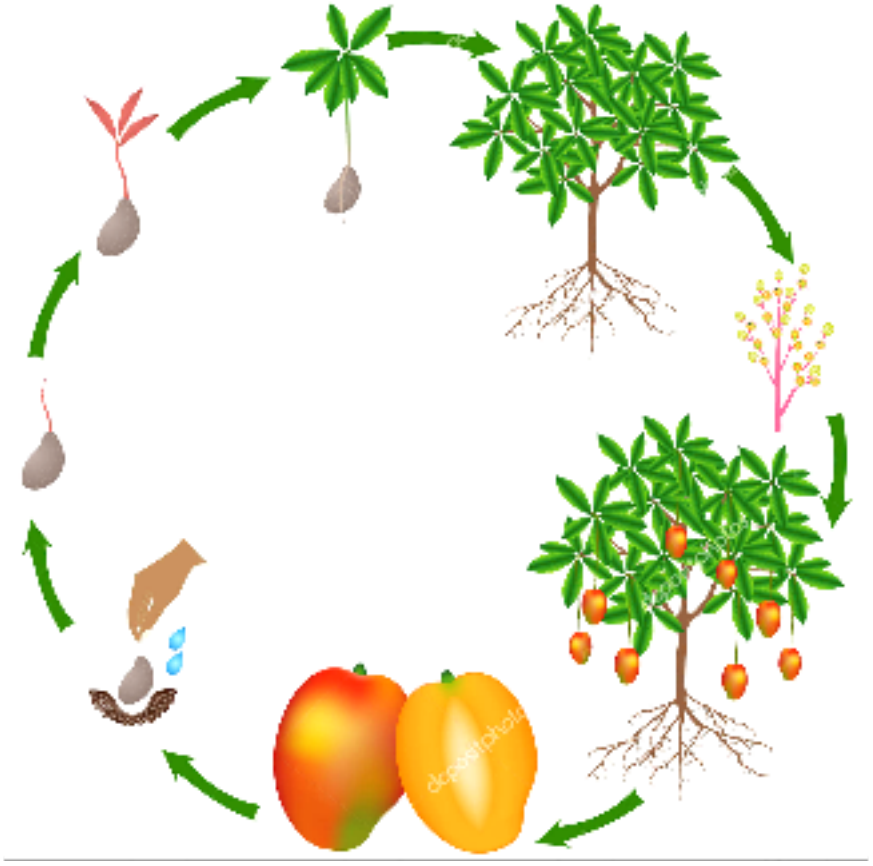


Figure 6 shows the life cycle of Mangifera indica (Vector de stock (libre de regalías) sobre Life Cycle Mango Plant On White1146883289, n.d.)

The process is described above in The life cycle section

3.2.2 Phenology

Mangifera indica has two types of phenological growth stages (Pedro Modesto Hernández Delgado, 2011). One describes five stages for shoots, which consist of stems including their appendages, leaves, lateral buds, flowering stems and flower buds. The other phenological growth stage shows nine stages for inflorescence development, meaning the group or cluster of flowers arranged on a stem that is composed of a branch and its development (Pedro Modesto Hernández Delgado, 2011). *Mangifera indica* produces many

vegative flushes (shoots) during the summer and autumn and are more consistent than the flowering stages which occur during winter and early spring (Pedro Modesto Hernández Delgado, 2011).

3.3 Reproductive Biology

3.3.1 Sexuality

Mangifera indica has male and hermaphrodite (bisexual) flowers, with both of them mixed in the same strain. Strangely, there are no female ones (Shu, 2009). The flowers are a yellowish violet color, have 5 petals and are around 0.6 to 0.8 cm long (*Mango | Mangifera Indica l. | | Flower Database*, n.d.). Below figure 7 shows *Mangifera indica's* flowers.

Figure 7 shows Mangifera indica flowers. (Mango | Mangifera Indica l. | | Flower Database, n.d.).

3.3.2 Pollen

Mangifera indica's pollen can be observed on both male and hermaphrodite flowers (Pérez et al., 2019). Several studies have observed that pollen performances increase in higher temperatures, consequently decreasing in lower temperatures (Pérez et al., 2019).

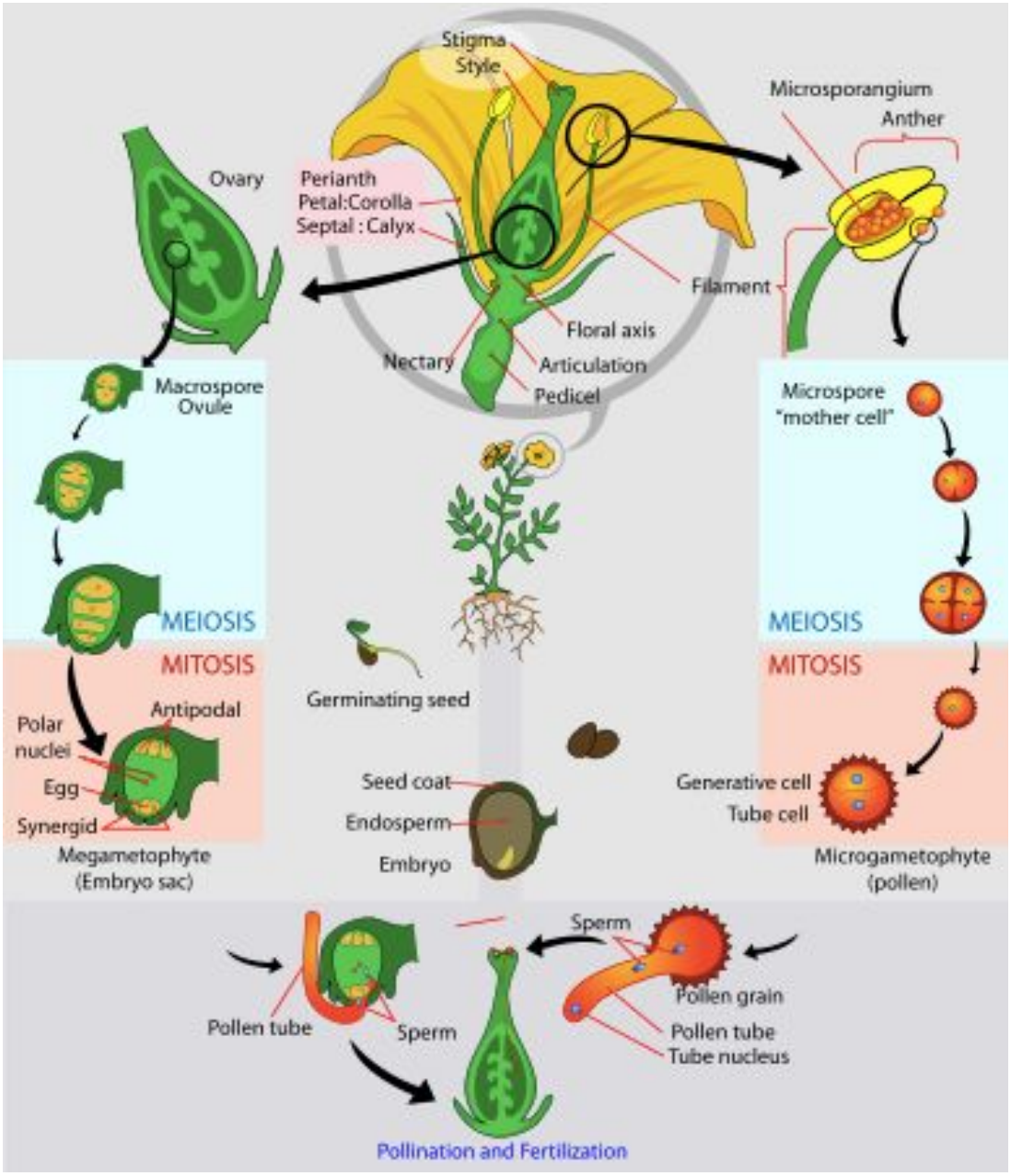


Figure 8: Shows Mangifera Indca's pollination and Fertilization Processes (Chelsea Ruda, 2012)

3.3.3 Pollination and potential pollinators

In the absence of pollinators, *Mangifera indica* is unable to produce any fruits (Nurhul Huda, 2015). On average, during natural conditions, cultivars produced 4% fruit set per

flower (Nurhul Huda, 2015). Pollinators contribution to *M. indica*'s fruit set was estimated to be about 50%, which include large sized flies such as *Eristalinus spp*. and *Chrysomya spp* (Nurhul Huda, 2015). Below Figure 8 shows a *Eristalinus spp* fly pollinating a mango flower.

Figure 9: Eristalinus spp fly pollinating a mango flower (Modesto Pérez, 2018).

3.3.4 Fruit development and seed set

3.3.4.1 Fruit development

Mangifera indica's fruit development occurs during the dry season farmers therefore have to irrigate mango trees in order to ensure good quality of the fruit (Spreer et al., 2009). It

can take about four years for a seed of mango to transform into a tree who gives out fruit (Spreer et al., 2009).

3.3.4.2 Seed germination and seedling growth

M. indica seeds germinate at temperatures ranging from 5º- 40º C, preferring temperatures of 25ºC(Corbineau et al., 1986). The optimal growth for seedlings is around 30 degrees C, high temperatures reaching 40 degrees C, and lower ones within 15 degrees C, can be lethal for its growth (Françoise Corbineau, 1986). Figure 10 below shows the effect of temperature on seedling growth through the course of time.

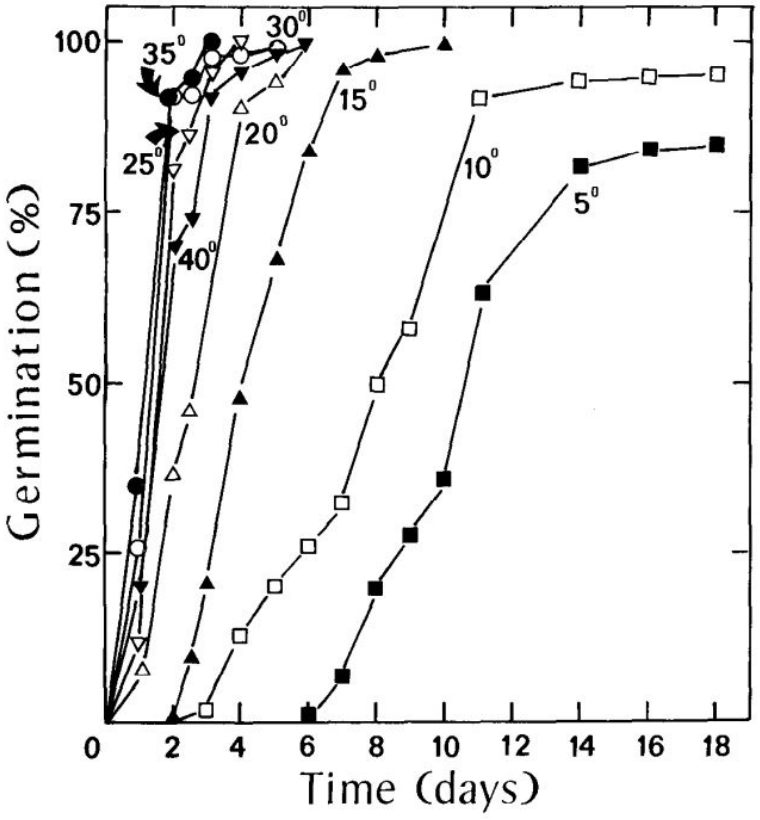


Figure 10: Effect of temperature on seedlings of M. indica (Corbineau et al, 1986).

The graph shows the germination percentage of the seeds over the days given a certain temperature.

Chapter 4: Propagation and management

4.1 Natural regeneration

M. Indica's natural regeneration is really weak in general, more so in forest areas, this is due to it being a mono-embryonic variety (Cheravengat, 2012). During several studies regarding natural regeneration of sub tropical plant varieties an interesting observation was made. Elephant's were the ones who contributed the most by eating the mangoes and defecating them, spreading the seeds all over the place (Cheravengat, 2012), as can be seen below in Figure 11. It was recorded that more than 52.2% of the seedlings observed were able to survive and grow in one year. Well after two years the survival rate for the seedlings dropped to 26.6%, but what's important about this is that elephant's gut secretions provide suitable conditions for M. Indica's germination (Cheravengat, 2012).

Figure 11: Shows elephant eating mangoes (Sarvesh, 2011)

4.2 Nursery propagation

4.2.1 Propagation from seed

Mangifera Indica is mono-embryonic, which means that there will only be one seedling from the a seed. (Al-Busaidi et al., 2016). The common methods of propagation aren't very practical and effective with *M. indica* (d Al Busaidi et al., 2016).

4.2.2 Vegetative propagation

Vegetative propagation is a common method to propagate monoembryonic mango such as *Mangifera indica* (Al Busaidi et al., 2016). Due to *M. Indica's* inability to be

propagated by conventional methods,vitro regeneration is utilized, which is the growing and multiplication of cells, tissues and organs in controlled environments (Al Busaidi et al., 2016).

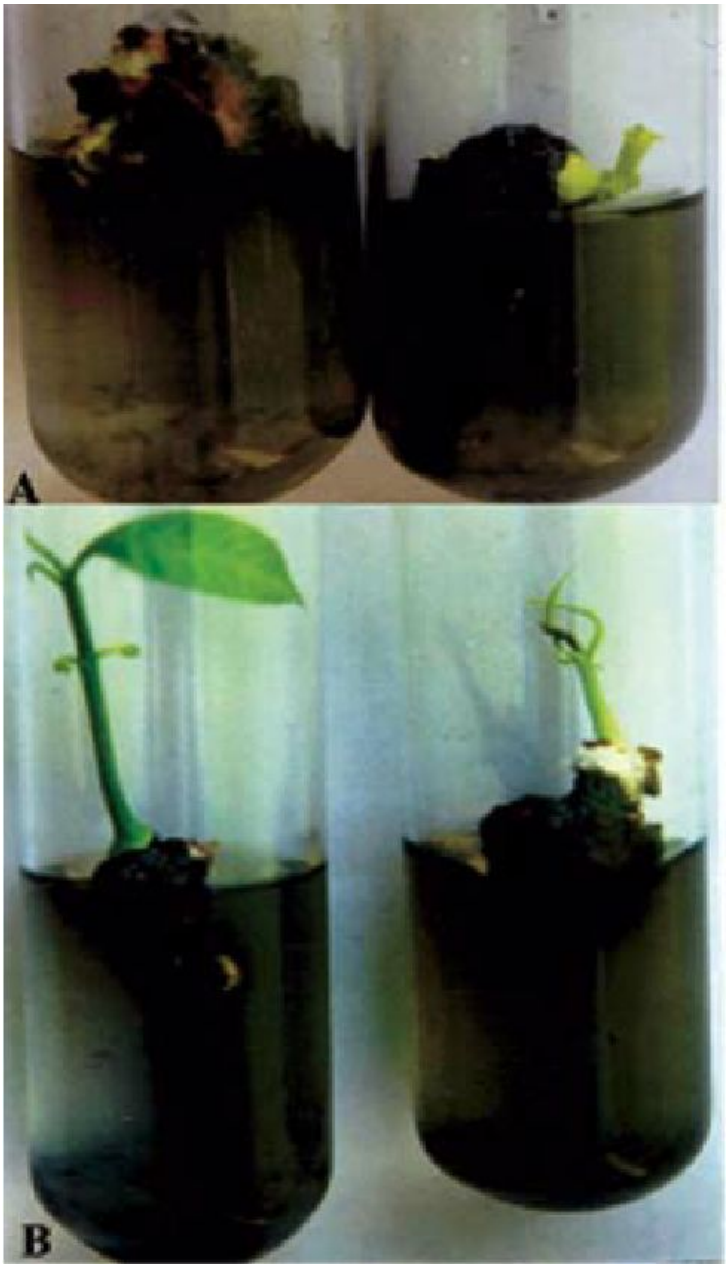


Figure 12: Shows The Growth of mango seeds through the process of vitro regeneration (Muhammad Usman, 2005, p. 1).

4.3 Planting

Mangifera indica is a very common tree all over the tropic and subtropic areas of the world. There aren't any current programs for it's restoration since there are plenty. For information regarding *M. Indica's* planting conditions head back to chapter two.

4.4 Management

4.4.1 Tending and fruiting

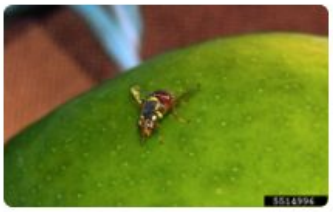
M. Indica's tending and fruiting was previously mentioned, and can be found back at chapter two, section two.

4.4.2 Pest and disease control

4.4.2.1 Pests

Mangifera Indica has over 170 types of pest. The most destructive ones from the insect category include weevils, fruit flies, scales, mealy bugs, dermestids,eye flies and drosophila. They are controlled by spraying storage shade and around the area with 0.02% phosphamidon and treating fruits with 0.03% Azadirachtin or keeping fruits in hot water 50 to 52o c for 2 to 3 hours. On the other side the rodent pests include Rattus rattus and Bandicota indica which can be controlled by keeping poison baits in their nesting and visiting places. (Bhoje et al., 2014).

Fruit fly maggot (Anastrepha spp.) feeding on mango pulp



Adult fruit fly (Bactrocera obliqua) on mango fruit

Adult fruit fly (Bactrocera frauenfeldi)

Fruit fly, Bactrocera jarvisi on mango fruit

Predation of fruit fly larvae (third larval instar) by weaver ants

Leaf hopper on new mango leaf

Mango leafhopper (Amritodus atkinsoni)

Adult mango tree borer

Adult mango tree borer (2)

Figure 13: Shows Mangoes pests with their corresponding name within the picture (Bhoje et al., 2014).

4.4.2.1 Diseases

M. Indica also has its share of diseases, which include Algal leaf spot, Anthracnose, Powdery mildew, Sooty mold and Bacterial black spot (Plant Village, n.d.). Their treatment will be listed in the following sentences. For algal leaf spot, Ensure that trees are properly pruned and fertilized to promote vigor; remove all weeds from around tree bases; employ a wider tree spacing to increase air circulation around the trees; badly infested trees can be treated with copper containing fungicides. If Anthracnose is identified the recommended treatment is an application of an appropriate fungicide which can be applied by spraying or painting onto infected bark with a paintbrush. Fungicides are very effective at controlling powdery mildew if applied at the first sign of the disease; chemical sprays only need to be applied at flowering and fruit set. If plants are small, wash mold with a strong stream of water, spraying starch also removes sooty mold, control sap sucking insects and also keep the trees free from ants by applying a sticky compound around the trunk. For Bacterial black spots, provide windbreaks for plants; prune out infected twigs; protective sprays of copper during wet weather help to protect plants from the disease (Bhoje et al., 2014).

Algal leaf spot

Green algae (Cephaleuros spp.)

Anthracnose symptoms on mango

Anthracnose symptoms on mango

Anthracnose symptoms on mango

Anthracnose symptoms on mango fruit

Anthracnose symptoms on mango fruit

Anthracnose symptoms on mango fruit

Anthracnose symptoms on mango fruit

Powdery mildew symptoms on mango panicle

Powdery mildew symptoms on mango leaf

Mango powdery mildew: leaf symptoms

Powdery mildew symptoms on mango leaf (2)

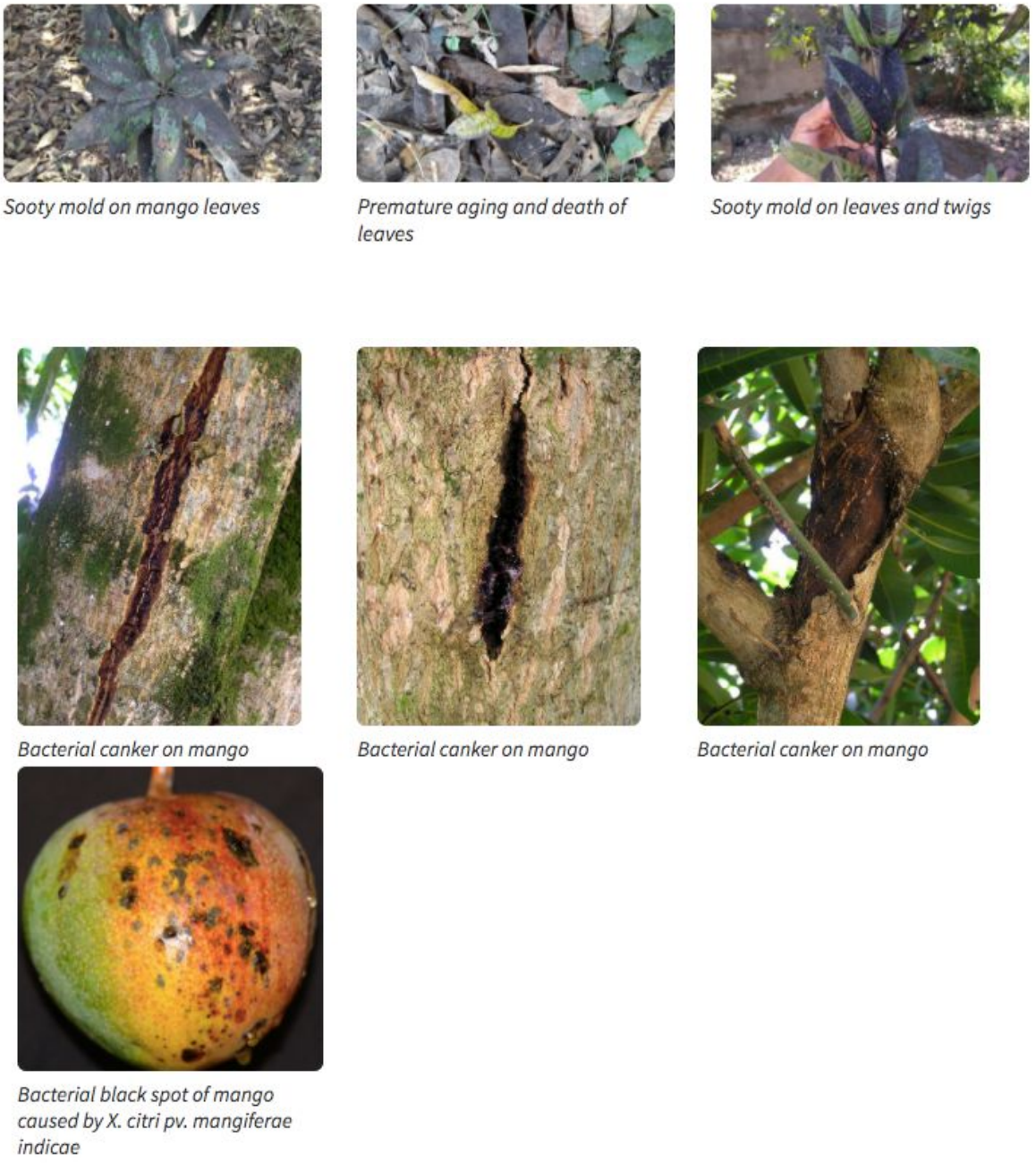


Figure 14: Shows mangoes diseases with their corresponding name within the picture (Bhoje et al., 2014).

Chapter 5: Market and uses

5.1 Market

M. Indica has a worldwide market, overcoming its tropical and subtropical natural growing areas. Its commerce of imports and exports is one of the largest among fruits making it worthy of its title "The King of Fruits" (Fresh Plaza, 2020). The largest importers and importers (of 2017) will be shown in the tables below.

Table 2: Shows the countries who import mangoes the most. This information was taken from (FAOSTAT, 2017).

Country	Unit	Import quantity
United states	Tonnes	485,477
Netherlands	Tonnes	212,916
Vietnam	Tonnes	153,700
United Arab Emirates	Tonnes	87,504
Germany	Tonnes	87, 349
United Kingdom	Tonnes	83,567
France	Tonnes	62,145
Malaysia	Tonnes	61, 389
Spain	Tonnes	43,428
Saudi Arabia	Tonnes	39,246

Table 3 Shows the countries who export mangoes the most. This information was taken from (FAOSTAT, 2017).

Country	Unit	Export quantity
Mexico	Tonnes	435,815
Thailand	Tonnes	244,480
Netherlands	Tonnes	184, 896
Brazil	Tonnes	179,744
India	Tonnes	172,441
Peru	Tonnes	162,938
Vietnam	Tonnes	111,930
Ecuador	Tonnes	58,994
Spain	Tonnes	41,523
Côte d' Ivoire	Tonnes	41,124

5.2 Uses

M. Indica's main use is as a delicious food and it can be sweet or sour depending on the time it is harvested and eaten. (Sushmita Sengupta, 2018).

5.2.1 Medicinal uses

Eating Mangoes can help with your digestion, it contains enzymes that aid the breakdown and digestion of protein, and also fibre, which keeps the digestive tract working efficiently. It also boosts your immune system, this is due to the large amount of vitamin C a

mango poses. Eating mango promotes eye health, mangoes are rich in beta-carotene that helps in the production of Vitamin A. This antioxidant helps improve vision, boosts overall eye health and prevents age-related degeneration or loss of vision. Its consumption can actually lower cholesterol, The high levels of fibre bring down the low-density lipoprotein which causes plaques in the vessels and blocks blood flow. As mentioned before mango contains large amounts of vitamin C and helps produce vitamin A, these vitamins are key factors for clear skin, which is another amazing benefit of eating mango. And Finally Mangoes, eaten in moderation, can help in weight loss. The phytochemicals in the mango skin act as natural fat busters and its flesh is filled with dietary fibres. (Sushmita Sengupta, 2018)

5.2.2 Processed uses

Mangoes are processed at two stages of maturity, the green stage and Ripe stage. The green fruit is used to make chutney, pickles, curries and dehydrated products. The Ripe Mangoes are used as canned and frozen slices, purée, juices, nectar and various dried products (Dauthy, 1995).

Figure 15: Shows a variety of processed mango products (Jinnah, 2013).

5.2.3 Other uses

As the fruits uses have been stated it is also worth mentioning the leaves and trees utilization. Due to *M. Indica's* tree size is often used in landscaping as a shade tree, and if planted in groups as a hedge or screen (Gillespie, 2017). In the other hands the leaves are useful for managing diabetes leaves of the mango tree contain tannins called anthocyanins that may help in treating early diabetes (Sushmita Sengupta, 2018)

figure 15:Mango tree acting as natural shade (Sushmita Sengupta, 2018)

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invernadero gracias a la empresa Polyfly #IFAPAChurriana #subtropicales #controlbiologico @IfapaJunta https://t.co/Q5AfWRHHv5" / Twitter. Twitter. https://twitter.com/modelpino/status/986684236127227904/photo/2

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