Botany

The CCA Cherimoya Handbook

Table of Contents

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Introduction

The cherimoya (*Annona cherimola* Mill.) is among the better known fruits of the custard-apple family Annonaceae. It is closely related botanically to the native American pawpaw (*Asimina triloba* L.), which is found along the Mississippi River and in other valleys of Central and Eastern United States.

While the cherimoya has been planted in most tropical and subtropical areas of the world as a door yard tree and in small orchards, it is presently grown on a commercial basis only in a few subtropical areas in Spain, Italy, California, Chile, Peru, New Zealand, Australia, and Israel.

A closely related hybrid, the atemoya (*A. squamosa* X *A. cherimola),* is grown in the more humid areas of Florida, Australia, and Israel. The sugar-apple (*A.squamosa* L.) is the major custard apple grown in the tropical areas of India, Egypt, and in Central and South America.

The botanical family Annonaceae is of ancient origin as indicated by the primitive floral characteristics of numerous stamens and carpels arranged in a spiral manner on the central floral axis.

The spiral arrangement is a feature common to members of the botanical order Ranales and is shared with other primitive plant types such as Magnolias.

Paleobotanical specimens of a very ancient form of the modern custard apple relatives have been uncovered in the Goshen fossil fields of Central Oregon and are dated with other Tertiary flora which existed about 25 million years ago.

The genus Annona is represented by several endemic species in Central and South America and one in Africa. There are no Annona species native in Asia. Many members of the present day Annonaceae originated in the semitropical regions of northern South America.

The cherimoya and other closely related species with large edible fruits can be traced to the highlands of Peru and Ecuador where they presently exist in a wild state.

With the development of world exploration and travel in the 15th century, the attractive custard apple fruits were eventually introduced into nearly all of the tropical and subtropical areas throughout the world.

Taxonomy

Cherimoya Botany

The botanical family Annonaceae consists of trees, shrubs, and vines with aromatic wood and foliage, alternate leaves without stipules, spiral arrangement of the stamens, ruminate endosperm, and hypogynous pistils.

The ovary has one locule and a single ovule attached at the base within the pistil. The family consists of 130 genera and about 2300 species.

Some of the better known and important genera are Asimina (8 species), Uvaria (many species of the Old World tropics), Annona (100 species of Tropical America), Polyalthia (70 species of Asia), Xylopia (60 species-pan tropic), Guatteria (60 species Mexico-South America), Oxymitra (50 species Asia), Artabotrys (40 species pan tropic), and Rollinia (50 species - American tropics).

Several important botanical relatives of the cherimoya produce fruits and products which are of considerable value to local ethnic communities and to the world in general.

The burahol (*Stelechocarpus burahol* (Blume) Hook.f. &Thompson) of Malaysia, bears a fruit about the size and color of an apricot and in great quantity along the trunk and large limbs of the evergreen tree. Ingestion of

Among the more commonly known species of Annona recognized primarily for their edible fruit are:

Annona cherimola Miller	- cherimoya (Peru-Ecuador highlands)
Annona senegalensis Pers.	- wild custard apple (South Africa)
Annona squamosa L.	- sugar apple or sweet sop (pan tropic)
Annona muricata L.	- guanabana or sour sop (tropical America)
Annona reticulata Saff.	- bullock's heart (tropical America)
Annona diversifolia Saff.	- ilama (tropical America)
Annona glabra L.	- pond apple (southeastern U.S.)
Annona purpurea	- sonconya (tropical America)
Annona montana Macf.	- mountain sour sop (tropical America)
Annona cacans var. *glabriuscula* Fries	- articum (Southern Brazil)
Annona hybrid	- atemoya (*A. squamosa* X *A. cherimola*)

Other botanical relatives of interest because of their fruit or plant product are:

Asimina triloba L.	- eastern or American pawpaw (Southeastern U.S.)
Cananga odorata ((Lam.) Hook f. and Thompson)	- ylang-ylang, perfume (tropical Orient)
Rollinia deliciosa Saff.	- biriba (tropical America)
Anonidium mannii	- jungle sop (tropical Africa)
Hexalobus monopetalus ((A. Rich) Engl. & Diels))	- baboon's breakfast (West Africa)
Monodora jundodii Engl.& Diels	- African or Calabash nutmeg (Southwest Africa)
Uvaria kirkii Oliv. ex Hook f.	- monkey banana
Xylopia aegyptica Duval	- African pepper, grains of paradise (tropical Africa)
Polyalthia spp. Blume	- ornamental (India East Africa)
Duguetia quitarensis Benth	- lancewood (British Guiana)

the fruit is said to reduce natural body odors.

The ylang-ylang (*Cananga odorata*) is a tropical tall tree which produces masses of highly fragrant flowers that are distilled to provide the basic essential oils widely utilized in the French perfume trade. Commercial plantations of the ylang-ylang are found in Madagascar and Reunion.

Attractive ornamental genera such as *Polyalthia* spp. grow in the warmer areas of India and Sri Lanka. Many African genera supply products of native foods, among which are *Xylopia aegyptica* (African pepper), *Monodora* spp. (African nutmeg), *Hexalobus, Uvaria*.

There are others that provide dried products such as spices of value to local ethnic groups or small fresh fruits which are edible and nutritious. *Artabotryes brachypetalus* is a vine-like climber of Northern Transvaal in South Africa with clusters of small edible grape-like fruits. Another African species, *Friesodielsia obovata*, bears small clusters of red, edible "monkey fingers".

Hybrids

The ability to cross pollinate certain species of Annona has resulted in a number of inter-specific hybrids some of which are of considerable commercial value.

The tropical *Annona squamosa* crossed with the more cold tolerant *A. cherimola* has produced a series of intermediate forms which are carried in the trade under the name "atemoya".

The name "atemoya"was given to this particular hybrid by P.J. Wester who first produced some of the large attractive fruit forms in Florida in 1910. Other hybrids between several Annona species are presently being evaluated in Australia.

The Cherimoya Plant

The cherimoya is a relatively frost tender subtropical, semi-deciduous tree species which can reach a height of 25 feet. It generally retains its leaves throughout most of the year except during the early part of the flowering period when the leaf is abscised from the recent shoot growth to permit the length growth of the lateral buds.

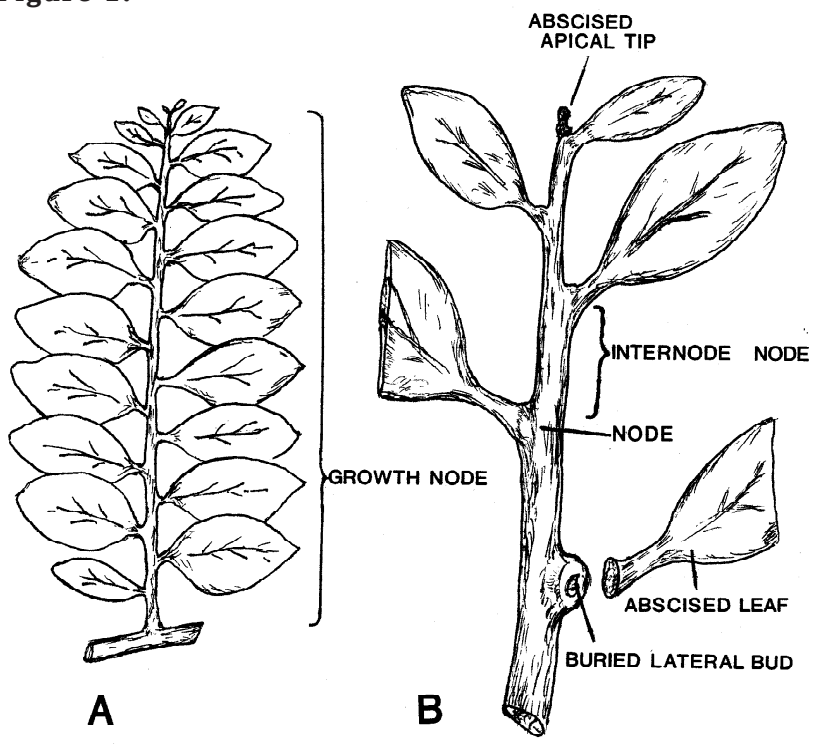
Lateral buds are exposed by leaf fall to develop and provide shoot length growth, or to develop as flower buds, or as a combination of both. The lateral buds are not formed in the leaf axil but are buried in the base of the swollen petiole hence they are called subpetiolar buds.

Thus the leaf must abscise before lateral growth and flower bud development can then proceed. Occasionally latent buds appear on older branches and along the main trunk to develop as flower or leaf buds or a combination of both. Such latent flower buds can give rise to normal fruits if pollinated.

The location and development of subpetiolar buds in the cherimoya is a unique phenomenon among cultivated fruit species.

The tree canopy consists of simple, entire leaves arranged alternately on shoot growth of

Figure 1.



A. Lateral branch showing alternate leaf insertion along a growth node.

B. Tip of recent shoot growth showing absised leaf with buried lateral bud and abcised (withered) apical tip still attached.

the current season. The number of leaves on a given current shoot may range from one or two to 25 or more.

Leaves are simple, 10 to 30 cm long, ovate, bluntly pointed, rounded at the base, and borne on a short, swollen petiole. The leaf blade is relatively thin, sparsely hairy above, and velvety beneath. Midribs and veins on the lower leaf surface are tomentose.

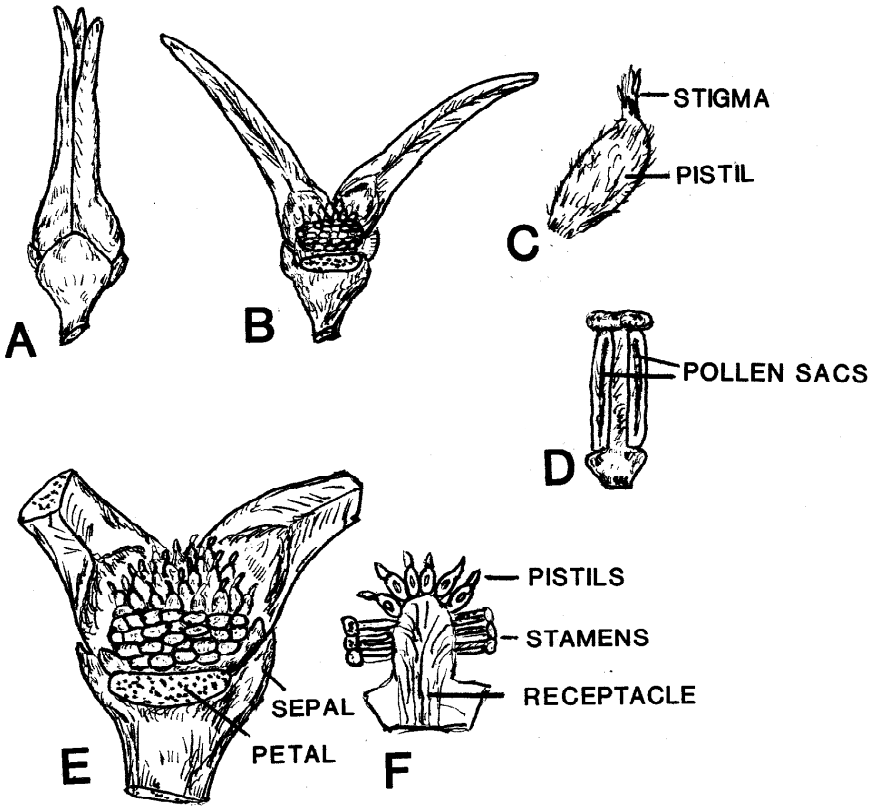
The leaf edge is entire. Small oil cells located in the palisade tissue is a structural feature of the botanical family Annonaceae. Young leaves and immature shoots are covered with a soft brownish hairy indument. Older leaves tend to become glabrous with multiple hairs remaining primarily along the midrib and larger veins on the lower surface.

The leaf structure consists of an upper epidermis of brick-shaped cells covered by a protective layer of cutin. Beneath the upper epidermis is a layer of vertically elongated palisade cells containing chlorophyll tissue in which much of the photosynthetic activity takes place.

Scattered among the palisade cells are prominent oil cells, the idioblasts, each of which contain a large drop of oil which provides the characteristic odor when the leaf is crushed.

The spongy tissue beneath the palisade layer consists of loosely packed, rounded parenchyma cell, separated by much intercellular space. The lower epidermis is punctuated by many stomata and in immature leaves by numerous and sometimes branched leaf hairs arising from epidermal cells.

Figure 2. Structure of cherimoya flower



A — Pistillate stage (petals tight)

B — Staminate stage (petals relaxed)

C — Individual pistal

D — Individual stamen

E — Sketch of staminate stage showing spiral arrangement of stamens and pistals

F — Sketch of section through flower showing position of stamens and pistels on receptacle

Flowers

Cherimoya flowers are usually borne singly, but clusters of two to five or more can appear at a given node under some conditions. The large fleshy petals are slightly velvety and greenish on the outside, with a smooth white glabrous inner keeled surface and a maroon blotch in the broad concave base.

The fleshy corolla consists of two whorls of petals. Three or more thick, fleshy outer petals, which range from approximately one to three inches in length and taper to a point from the base, are attached to the floral receptacle.

Inserted between the outer petals at their base are three small inner petals, sometimes called tepals, each about 1/8 inch in length. Occasionally one or more of the inner petals may attain the size of the outer petals, resulting in an aberrant irregular number of petals in a given flower. Subtending the two whorls of petals are three flattened, fleshy sepals alternating with the large fleshy outer petals.

Within the center of the flower is the apical mass of carpels, arranged spirally, attached to the central receptacle, and oppressed loosely to each other at their bases. Each carpel consists of a simple ovary within which a single ovule is attached at the basal end. The stigma, sessile on the ovary with little indication of a style, is long-triangular in shape, consisting of papillae upon which the pollen is received.

Subtending the pistil mass is a ring of many stamens, up to 200 or more, tightly packed together and arranged spirally around the base of the receptacle or torus. Each stamen is about 1/16 inch long, consisting of a flattened, thread-like filament from which is suspended on the lower side two long pollen chambers, each of which dehisce longitudinally to release the pollen grains. The outer end of the stamen is flattened to form a shield-like, fleshy structure.

Pollen grains produced in the anthers frequently are shed as tetrads or clusters of four grains clinging together. The retention of the mature pollen grains in this tetrad form is characteristic of many members of Annonaceae.

Most plant species shed their pollen as single grains. All four grains of the cherimoya pollen tetrad can germinate simultaneously and apparently are functional. Tetrads are easily separated by a slight mechanical pressure into single grains. The pollen grain is nearly spherical in form, about 50 microns in diameter.

The nature of flower maturation and floral behavior in the cherimoya exhibits the phenomenon of dichogamy, a condition in which the maturity of the two sexes in a given flower does not synchronize.

The specific situation which prevails in the cherimoya is termed protogyny, a condition where the female elements or stigmas are receptive when the flower first opens, but pass this stage of receptivity prior to the release of pollen in the given flower. Such a condition, if strictly effective, precludes self-pollination within a given flower and implies the need for cross pollination with pollen from another source.

In its normal sequence of development the mature cherimoya flower will separate its petals slightly at the tip early in the morning, at which time the central mass of stigmas deep within the flower is glistening white, covered with a viscous fluid, and is receptive. Beneath the pistil mass is the ring of many tightly adherent, white stamens which are not shedding pollen.

In the mid afternoon the petals will separate widely to a position of 180 degrees. The central pistil mass at this time will have turned brown and become dry and unable to accept pollen. The stamen mass changes to a cream color, and the individual stamens will separate slightly from each other.

These events allow the pollen chambers to dehisce and shed the fine white pollen. The mature pollen now can be transferred to flowers which are still receptive or can be retained under proper conditions for use in hand pollination transfer later.

Maturation of the cherimoya flower is associated with the development of a strong, attractive, and pleasant odor described by many as that of banana oil or amyl acetate. It is suggested by some observers that the emitted odor provides an attractant for insect pollinators.

The role of floral odor and that of possible natural insect pollinators in the cherimoya flower are yet to be established with certainty. Extensive field observations on the natural pollinating insects in many species in the Annonaceae have been made by a group of investigators associated with the University of Utrecht in the Netherlands.

A number of insects especially some of the beetles (Coleoptera), have been closely associated with fruit set in many Annonaceous species. Unfortunately these field studies have not included the cherimoya or its hybrids.

More recent observations made specifically on cherimoya and the atemoya in Israel and Australia have indicated a possible role of the Nitidulid beetle and the “dryfruit beetle” in fruitset under some conditions. Flower thrips also have been suspected of being effective in the pollination of cherimoya flowers. Some current studies in Spain indicate that the pirate bug, *Orius* spp., possibly can transfer cherimoya pollen.

Recent observations in California indicate that a “Rove” beetle (Staphylinidae) about 2 mm. long, may play a role in natural fruit set in some areas. Many observations and some experimental trials have shown that the domesticated honey bee will collect pollen from the cherimoya flower, but will not transfer this pollen to receptive flowers.

The common fruit fly (*Drosophila melanogaster*) probably does not play any role in cherimoya pollination.

The cherimoya flower will normally set and develop fruit only after adequate pollination has been provided either by insect pollinators or through the transfer of pollen by hand techniques.

Most cherimoya cultivars set fruit of acceptable size only when several of the pistils have been pollinated. The formation of each seed requires the transfer of a pollen grain to the stigma and fecundation of the egg cell to form an embryo and its supporting tissues.

In general, the more seed that are formed the larger the fruit will result. Fruits with one or two seed may weigh just a few grams. Large fruit with a hundred or more seed can attain very large size and weigh more than two kilograms.

The ratio of flesh to number of seed is greater in some cultivars. Large seedless cherimoya fruits have been reported. but regular production of such fruits has not been demonstrated.

Seedless fruits can be induced by repeated application of gibberellic acid, but the resulting fruit is costly and often of questionable quality; hence, this method of fruit production is not yet commercially feasible.

The Fruit

The fleshy fruit of the cherimoya is known as a syncarpium, a specific type of fruit structure which results from the fusion of several individual carpels or pistils borne within a single flower.

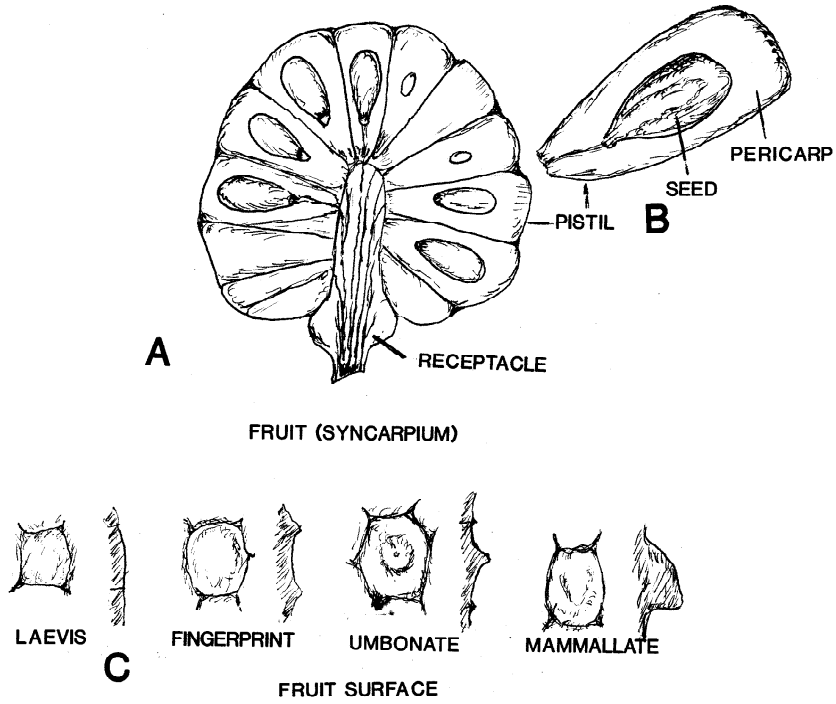
The several carpels of the cherimoya, which are at first distinctive and separate in the freshly opened immature flower, eventually become compressed together and actually fuse at their bases as the seeds develop.

Growth of the fleshy tissues around each seed results in the fusion of tissues near the receptacle. Thus the individual carpels cannot be separated at fruit maturity.

Individual carpels of the sugar apple, however, are frequently loosely attached and separate easily as individual fruitlets.

Demarcations of the several carpellary segments in the cherimoya are indicated on the external fruit surface either as dark lines or as raised tubercle-like structures or as impressions, as

Figure 3.



A — Median section through mature fruit showing attachement of pistils to receptacle.

B — Single pistil showing position of seed in percicape

C — External characteristics of fruit surface in tangential and vertical section of skin

if the soft surface was pressed by a fingertip.

Cherimoya fruits are sometimes classified and described with respect to surface characteristics such as smooth (laevis), finger-printed, umbonate (shield-like), or mammalate (with long or prominent, raised points).

The major portion of the fruit tissue consists of thin walled parenchyma with generally rounded or isodiametric cells in which the sugars, acids, and other soluble materials are stored. These cells comprise the pericarp, the soft edible tissue which surrounds the seed of each carpel.

Starch is found in these cells as are oil cells scattered through the pericarp tissue during the immature stages. Located a few cells beneath the epidermis or skin are small clusters of stone cells, the sclerenchyma, with thick, lignified cell walls.

A layer of simple uniform brick-shaped cells comprise the epidermis, which envelops the entire fruit. Surface hairs are found in the younger fruit but are generally lost when the fruit reaches maturity.

Scattered throughout the epidermis are specialized doughnut shaped cells, the stomata ,providing passages for the exchanges of gases in the fruit tissues.

The central fruit stalk, the receptacle, to which the several pistils are attached consists of lignified fibers, sclereids and much vascular tissue, xylem, and phloem, to support and conduct nutrients to the pistils.

The Seed

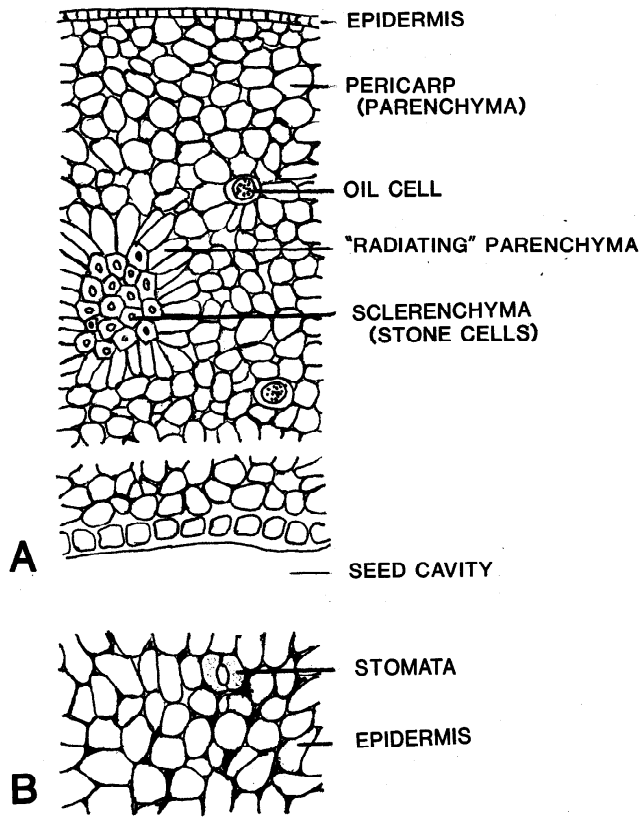
The seed of cherimoya is a prominent brown structure about 1 to 2 cm long, 1 cm wide and 5 mm thick. The size can vary considerably between cultivars.

The shape is somewhat oval and slightly pointed. Internally the major tissues of the seed are two compact, thick seed coats surrounding a prominent pleated or folded ruminate white endosperm. A very small, white embryo 1 to 3 mm in length is embedded near the hilum.

Seed germination follows the general pattern of seed with massive endosperm. The radical and primary root emerges from the hilum end or point of attachment of the seed.

Upon reaching the soil the continued growth of the hypocotyl or hook of the seedling enlarges and is extended and straightened to the vertical position. Thus the remainder of the seed including the cotyledons or primary seed leaves, are lifted into the air. Shoot growth and appearance of regular leaves then follows.

Figure 4.



A — Section through fruit percicarp showing position of oil cells and stone cells

B – Surface view of fruit epidermis with stomata

Shoot Growth

Shoot growth is initiated upon the abscission of the mature leaf, thereby exposing the lateral subpetiolar buds. The lateral bud contains the primordia of potential flower buds, vegetative buds or a combination of both.

The flower bud may continue to develop as a single flower, or sometimes clusters of two to six or more floral buds may appear at a given node. Lateral shoot length growth can continue beyond the newly developed flower bud.

Fruit which sets will thus develop at the base of the new growth cycle within the leaf canopy. Length growth will continue at the apical point while the subtending leaves are expanding and becoming mature. Thus older, mature leaves are located at the base of the elongating shoots and immature leaves in various stages of development appear near the shoot tips.

Length growth of the shoot is terminated by the formation of an abscission layer close to the apical stem tip. The withered and dry shoot terminal thus indicates termination of length growth. Shoot tip abscission can occur while some of the subtending leaves are still immature.

A "growth flush", which includes all of the nodes and internodes of the lateral shoot, is often demarcated at its base by a swelling of the older stem tissues to form a "doughnut ring" or an enlargement of the stem from which point the growth flush appears to arise.

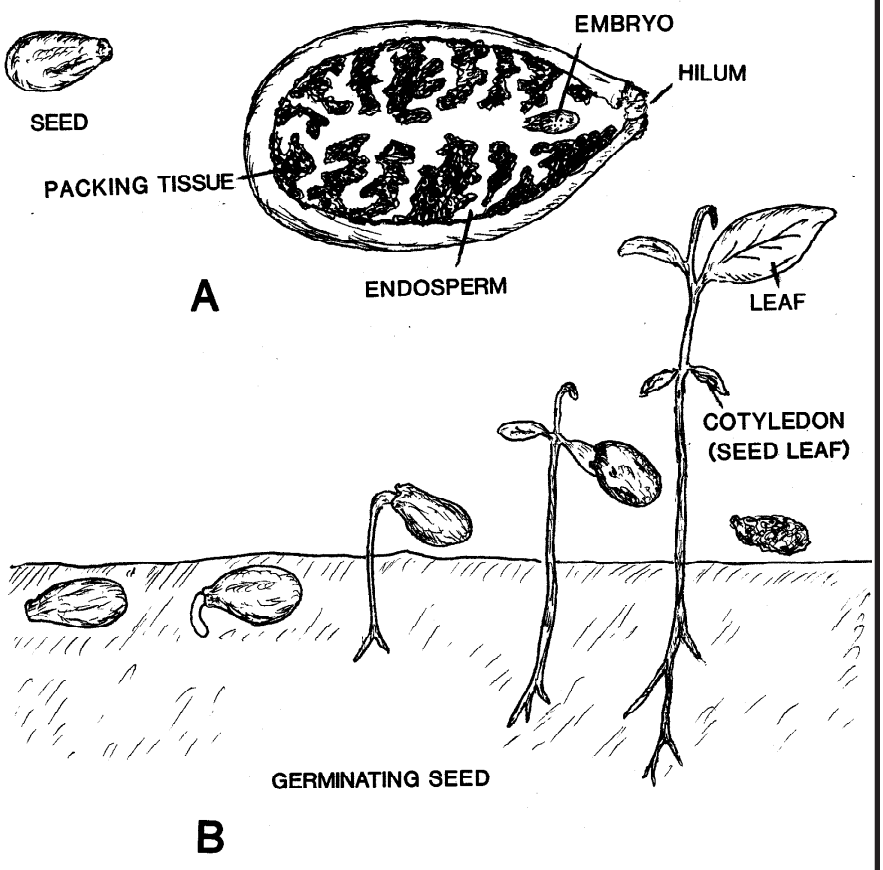
The length of a growth flush is highly variable and may involve a single internode and the terminal leaf extending 5 to 10 cms.; or this flush may develop a length growth involving more than 25 internodes to a length of 1 1/2 to 2 meters.

The vigor and extent of the growth flush will depend upon the several environmental conditions of soil moisture, soil fertility, temperature, and possibly other factors,

The nature of the leaf canopy is determined by the position of the leaf along the stem. The phyllotaxy of the cherimoya is described as 1/2 implying that the leaves are in opposite position in two rows along a shoot and alternate to the left and to the right in the same plane.

Twisting or distortion of the petioles results in the leaf canopy developing in an irregular pattern. The leaves of some atemoya cultivars tend to bend downward uniformally in two planes along the entire length of the shoot, resulting in a distinctive pattern of the canopy.

Figure 5.



A — Section through seed showing position of embyo in white endosperm

B — Stages in germination of cherimoya seed

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