PILI

INTRODUCTION

The pili (*Canarium ovatum* Engl.) is second to cashew in importance as a nut tree crop in the Philippines and has a great potential for development as a major export crop. In 1974-1978, 2,724 ha were planted to pili in the country consisting of 67,100 bearing trees with a yearly production of 4,631.7 tons (Table 15.1).

Table 15.1. Area planted to pili, number of trees and quantity of production by region *(7)*.*

Region	Area (ha)	Number of Trees (x 1000)		Production (t)
		Total	Bearing	
Southern Tagalog	368	23.4	6.4	106.9
Bicol	2,076	197.3	49.0	4,104.3
Western Visayas	10	0.9	0.5	3.2
Central Visayas	10	0.7	0.1	12.6
Eastern Visayas	226	15.1	10.0	387.6
Northern Mindanao	12	1.0	0.5	8.3
Southern Mindanao	22	1.0	0.6	8.8
Total	2,724	239.8	67.1	4,631.7

*Based on the average of annual (1974-1978) figures.

The Philippines is the only country that produces and processes the pili in some commercial quantity *(14)*. At present, the country enjoys a monopoly of the foreign markets for processed pili products. In 1977, for example, the Philippines exported 3,790 kg of pili nut preparations to Australia and Guam *(9)*. If the country can further increase local production through the use of improved varieties and can improve the quality and shelf-life of the processed products, it can substantially improve its foreign earnings from this fruit which is much in demand.

There are several reasons why the pili deserves to be developed. It is a very prolific tree with a yield that is comparable to or better than most other nut crops. Compared with other Philippine fruits, the pili is not perishable and thus, it can be grown in places remote from the centers of population without fear that the fruits will spoil if not marketed right away. If properly dried and stored, the nuts can be kept until the next harvest season, thus assuring a regular supply of raw materials even during the non-harvest months. In terms of human nutrition, the pili pulp and kernel are very nutri-

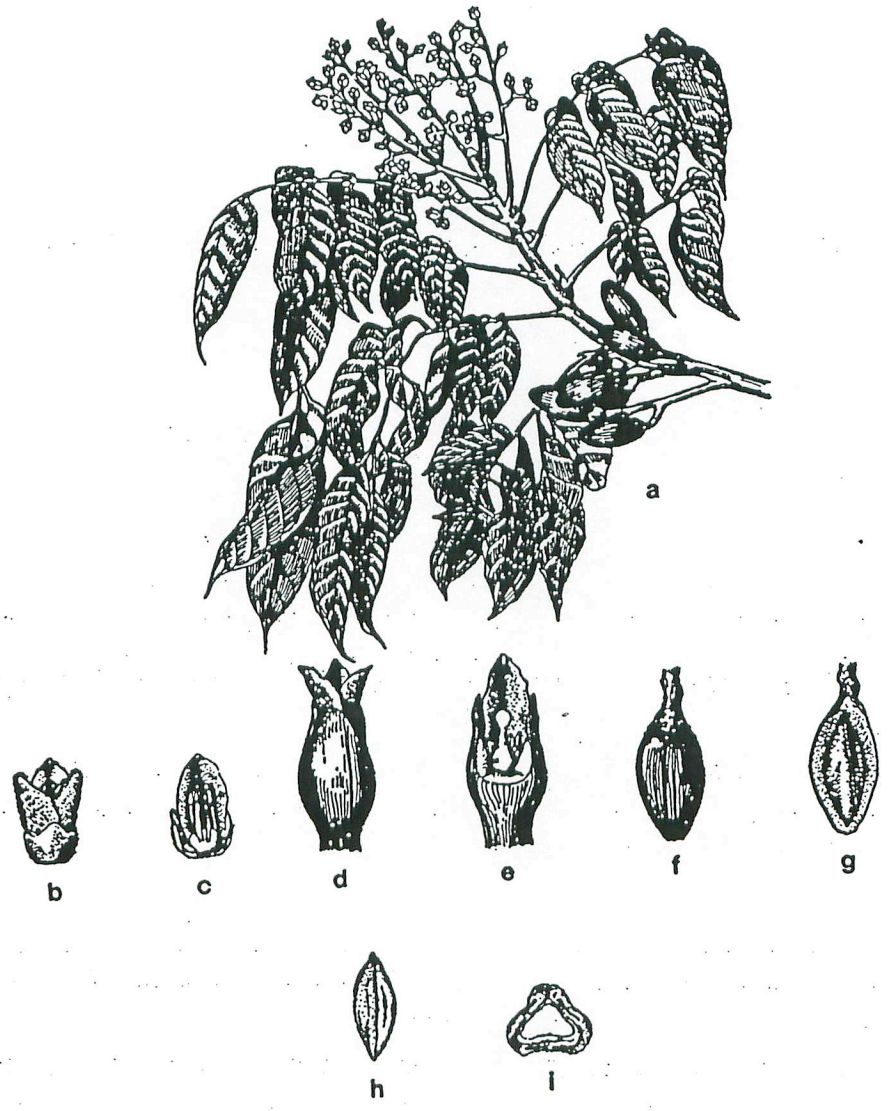

Fig. 15.1. Pili (*Canarium ovatum* Engl.). a. Flowering and fruiting habit, b. male flower, c. details of male flower, d. female flower, e. details of female flower, f. fruit, g. section of fruit, h. nut, and i. cross section of nut.

tious, being excellent sources of vegetable fats and proteins. For this reason alone, the growing of pili for local consumption deserves to be encouraged.

Despite its great promise, the pili seems to have been greatly neglected in the past. It used to be one of the 10 leading fruits in the Philippines, having been seventh in rank in terms of hectarage until 1958 *(12)*. Since 1958, however, the area planted to pili has generally declined. In 1958, plantings were estimated to cover more than 8,000 hectares. At the end of 1976, however, only about 2,550 ha were planted. This decline in hectares has been attributed to the indiscriminate cutting down of old but still productive trees for fuel and in making way for clearings *(29)*.

There are encouraging signs that the pili industry may be revived *(12)*. In 1978, the area planted had increased to 2,850 hectares. With the present effort of the government to use pili for reforestation, the area will certainly increase further. With the availability of planting materials from superior trees, it is hoped the pili will also be grown as an orchard crop.

ORIGIN AND DISTRIBUTION

The pili is indigenous to the Philippines *(30,31,32,50)* and is quite abundant and wild in Southern Luzon and parts of Visayas and Mindanao in primary forests at low and medium elevations and with evenly distributed rainfall *(2,6,22,29,30,31,38,46,47,48,50,52)*. No definite record exists as to when the pili became first known or when it became cultivated in the Bicol region *(29)*. It is still rarely cultivated *(22,29,30,31,48,50,52)* and practically all existing trees are from chance seedlings from fallen fruits carried away by birds *(29)*.

Production of the pili is primarily centered in the Bicol region *(12,17)*. The greater bulk of supply of raw nuts comes from Sorsogon, Albay and Camarines Sur *(48,50,52)*. In these provinces, the supply of raw nuts comes only from certain municipalities and barrios *(29)* usually located near the mountains. Southern Tagalog with 368 ha and Eastern Visayas with 226 ha also produce some pili (Table 15.1). In the other regions of the Philippines pili production is either quite negligible or none at all. To date there are no commercial plantings of pili in the Philippines *(12,17)*.

TAXONOMY AND NOMENCLATURE

The pili, *Canarium ovatum* Engl., is of the family Burseraceae. This family consists of 19 genera and about 400 species in the tropics of both hemispheres and is represented in the Philippines by 4 genera and about 40 species *(37)*. The genus *Canarium* which was derived from the Malay name *kanari* has about 100 species in tropical Asia and Malaysia and about 35 species in the Philippines *(37)*.

Also found in the Philippines are trees of the other *Canarium* species, such as kanari, *C. commune* L.; dulit, *C. hirsutum* (Willd.) f. *multipinnatum* (Llanos) H. J. Lam.; *C. villosum* Benth; bageja, *C. mollucana* Blume; pagsahingin, *C. aspersum* Benth.; pisa, *C. luzonicum* (Blume) A. Gray; and gisau, *C. vrieseanum* Engl. *(6,22,35,38,47)*. These species bear edible nuts that are important to people in some parts of the Philippines and other Southeast Asian countries *(11)*. Of these species, pili produces the largest fruit *(6,35)*. Pisa, another indigenous species, produces an oily resin from its trunk which is exported at present as Manila elemi *(11,34)*.

The pili is also known as *anangi, basiad, liputi, pilaui* and *pili-pilauai* *(6,12,22,52)*. There is some confusion in nomenclature because the pisa is also sometimes called pili *(55)* and basiad

BOTANICAL DESCRIPTIONS

Several authors have described the pili plant and its parts *(6,11,12,22, 28,33,38,46,47,48,50,52)*. The pili is a handsome, well shaped, semi-deciduous, medium sized to large tree reaching about 20-25 m high or more. It has a compact growth and rigid branches and a trunk diameter of about 40-50 cm or more. The large, compound, alternate leaves are about 40 cm long. The leaflets are odd-pinnate, rather thick, smooth, dark green, entire, rounded at the base, pointed at the tip, 10-20 cm long and prominently veined.

The pili is a dioecious species *(11,12,26,33,39,56)* with gametic chromosome number of 23 *(45)*. In the male and female trees, the flowers are borne on cymose inflorescences at the leaf axils of young shoots. The female inflorescence is about 7 cm long and has 3-6 female flowers while the male inflorescence is 9.7 cm long and has an average of 18 male flowers.

In the female flower, the calyx is saxcate, gamosepalous, about 1.5 cm long, 1 cm wide, and is composed of 3 thick, light green sepals. The 3 greenish yellow petals are about 2 cm long and 1 cm wide. The 6 non-functional stamens arise from the base of the pistil. The pistil is about 7 mm long and consists of a functional, superior ovary, a simple style about 1.5 mm long and 3-lobed stigma. In the male flower, the calyx is also saccate, 6 mm long, 4 mm wide, and is composed of 3 green sepals tinged with yellow orange at the tips. The 3 oblong, inwardly concave, greenish petals are about 10 mm long and 5 mm wide. The pistil is greatly reduced in size and the 6 functional stamens are also attached to the base of the vestigeal ovary. The ovary contains 3 locules, each with 2 ovules.

Some male trees are able to produce perfect flowers *(56)*. These perfect flowers are similar in all respects to the male flowers except that the former have functional pistils. They are capable of producing fruits although these fruits are much smaller than those from female trees. Pollen from these flowers are also capable of pollinating female flowers.

The fruit, commonly referred to as a nut but is botanically a drupe, is ovate to oblong in shape, 4-7 cm long, 2.3-3.8 cm in diameter and weighs 15.7-45.7 grams. It consists of a pulp, a shell and a seed. The pulp is composed of a thin skin (exocarp) which is smooth and shiny and turns from green to purple or nearly black when the fruit ripens and a fibrous, fleshy, thick mesocarp. The shell or endocarp is carpellary in origin. Its inner layer arises from the innermost epidermal cells surrounding the loculi while its outer layer develops from the numerous hypodermal cells of the endocarp. The shell is elongated and trigonous but in transverse section is nearly triangular with its corners rounded and one of its sides wider than the others. The basal end of the shell is pointed while the apical end is more or less blunt or obtuse. It is tawny to nearly dirty brown outside and more or less brown, shiny and glabrous inside. It measures 4.5-6 cm long and 1.5-2.5 cm in diameter. On the broad side of the shell which is often concave or elevated is the functional locule containing the mature seed and which also possesses on the outside distinct groves indicating the place where the shell breaks when the seed germinates.

The seed is made up of a brown, papery, seedcoat surrounding the embryo which has 2 white cotyledons (kernel). The kernel weighs 0.74-5.13 g and constitutes 4.4-16.6 percent of the whole fresh fruit by weight *(16)*.

FLOWER BIOLOGY

In both the male and female trees, the order of blooming of the flowers in the inflorescence is basipetal, that is, the oldest flower and the first to open is at the tip and blossoming proceeds downward *(33)*. Anthesis of both male and female flowers takes place between 4:00 to 6:00 p.m. Anther dehiscence and stigma receptivity take place at or immediately after anthesis. At anthesis, the flowers emit a fragrant odor indicating that they are basically insect-pollinated. The anther changes from white to yellowish at dehiscence and turns brown in the morning of the following day. Fruit set in flowers pollinated at anthesis averages about 87.5 percent while flowers pollinated at 24 hours after anthesis fail to set fruits indicating that pollen grains are shed at anthesis. The stigma is yellowish and sticky at the time of receptivity and begins to turn brown the following morning.

FRUIT GROWTH

When pollination is successful, the ovary begins to enlarge after 1 week and the petals start to drop off *(33)*. Fruit growth follows a sigmoid curve. Two weeks after pollination, the young fruit is dark green and there is no difference between fruit length and diameter. Then fruit growth becomes rapid up to the 10th-12th week with a more rapid increase in length compared with the diameter. Growth gradually slows down until it levels

off up to maturity. From pollination, the fruit takes about 10 months to reach maturity and its skin changes to purplish at ripening. At maturity the fruit is oblong in shape.

VARIETIES

Being a predominantly dioecious species, cross-pollination is the rule in the pili *(13,26)*. This results in the existence of numerous forms among seedling trees *(29)*. Studies conducted at the U.P. at Los Baños have shown that seedling trees exhibit a high degree of variability in sex, productiveness, fruiting season, growth habit, physical and chemical properties of fruit and other morphological features *(26)*. Almost half of the number of trees evaluated are male and the rest are female. The same results have been recently reported *(56)*. Among the female trees, some are very prolific while others are less productive. Some female trees are seasonal in their fruiting while a few trees produce fruits all year round. The trees also differ in fruit shape, size and weight; pulp weight and color; and kernel weight and percentage. The chemical composition of the kernels also varies (Table 15.6).

Table 15.2. Measurements of fruit and kernel characters of pili *(1)*.

Character	Range	Mean	Standard Deviation
Fruit			
Weight, g	15.72–45.69	25.71	0.94
Length, cm	4.03– 6.76	0.57	
Diameter, cm	2.33– 3.85	2.86	0.31
Kernel			
Weight, g	0.74– 5.13	2.73	0.08
Percent	4.40–16.61	10.71	0.25

Recent studies involving more pili trees have confirmed these earlier findings indicating that seedling trees differ greatly in fruit and kernel characters (Table 15.2) and in the composition of the kernel (Table 15.6). There is, therefore, an urgent need to select outstanding trees and to propagate them asexually *(12,17)*. This will eventually reduce, if not totally eliminate, the great variability existing among trees and will ensure maximum production of desirable fruits.

The selection standards for pili have been listed *(12,14)* and are described as follows:

Self-fruitfulness. Since the pili is a dioecious species, selection is being done only on female trees. Efforts, however, should also be made to locate hermaphrodite trees as is occurring in the papaya and rambutan. Herma-

phrodite trees are self-fruitful and planting them will totally eliminate the need for male trees. They can also be interplanted with female trees to make the latter fruitful.

Early bearing. On the average, pili trees take about 6-8 years or more to bear fruits when grown from seeds. It has been observed, however, that some trees may produce fruits as early as the second or third year. Precocious trees, therefore, should be selected as this character may be transmitted not only to their seedling progenies but also to plants asexually propagated from these early-bearing trees.

Productive. The pili, in general, is a very prolific tree. Full grown trees have been reported to yield as much as 5,000 kg nuts *(48)* and 10,000 fruits per tree *(29)*. A full grown, well-managed tree that produces half this quantity can be already considered very productive. To select high yielding trees, yearly records of production should be taken. The pili produces fruits reguarly every year and alternate bearing does not seem to be a problem.

Short fruiting season. Based on early findings that some trees bear fruits the year round, it has been suggested that ever-bearing habit is a desirable character *(12,26)*. However, since the nuts can be stored for an indefinite period, a tree that completes its fruiting in the shortest time possible is probably more desirable than one with an extended fruiting period. This will allow the tree to rest for a longer period before the next production while it will also reduce the cost of harvesting.

Large fruit, large kernel. The size and weight of the fruit are highly positively correlated with kernel weight *(16)*. Thus, the larger or heavier the fruit, the heavier is its kernel. In general, pili trees whose fruit weight is 30 g or more at harvest are to be considered outstanding, particularly if these trees are also prolific. Moreover, trees that produce short oblong to round fruits should be selected for more uniform roasting and more attractive appearance of the kernels.

Good kernel qualities. The pili is, by nature, a high protein- and oil-bearing plant. Its protein content averages 13.9 percent and its fat content averages 73.1 percent *(16)*. Trees that produce kernels with protein and oil content equal to or greater than the above mean values should be selected. The raw kernel should be almost wide in color with little or no discoloration. Trees that produce kernels with the characteristic turpentine odor should not be selected. Kernel texture should be tender and crisp and its flavor should be mild and nutty. Some trees bear fruits with bitter kernels and should be eliminated right away.

Good pulp quality. The pili pulp is edible when cooked and may also be processed into pickle and spread. It should not be fibrous in texture, bitter in taste and should not have a resinous odor.

Thin shell. The pili shell is, in general, much too thick to be opened by an ordinary nut cracker. A tree that produces thin-shelled fruit is, therefore, more desirable because this condition will be more amenable to mechanical processing.

Based on one or some of these selection standards, some work has been done on the evaluation of the pili. Wester recognized 2 forms based on the size of fruit: the short forms which are 4.5-6.0 cm long and the long forms which are 5.5-7.0 cm long *(48,54).* Both forms have similar percentage and chemical composition of kernel (Table 15.6). The short form is the one usually found in the markets while the long form constitutes only about 5-7 percent of the total quantity marketed. In another selection work based on yield and fruit qualities, 2 trees out of 95 were selected as outstanding in Los Baños, Laguna *(26).*

The first thin-shelled pili belonging to the long slender form was found in Magkasili, Guinobatan, Albay and was named 'Albay' after its province of origin *(54).* Another thin-shelled pili belonging to the short, broad form was found in Mauraro, also in Guinobatan, Albay, and was named 'Red' in honor of its discoverer *(54).*

Based on kernel weight, 40 trees were recently selected as promising in Laguna, Bicol and other places *(16).* The most outstanding tree in Los Baños, Laguna has been proposed to be named 'Katutubo' and is described below:

'Katutubo'. A seedling tree from seeds which came from Oas, Albay in 1919 and planted in the U.P. at Los Baños in 1920. It is medium-sized spreading tree, about 12 m tall, and with a trunk circumference of 163 centimeters. It has stout shoots and large, compound leaves 42.5-63.0 cm long and with 7-11 leaftlets. The leaflet is 14.8-20.0 cm long, 6.0-9.6 cm wide, concave, dark green above, light green beneath and elliptic. The petiole is 2.1-5.8 cm long. There are 3-6 fruits per cluster. The fruit is 6.8 cm long, 3.3 cm in diameter, weighs 45.7 g and oblong. The kernel weighs 5.1 g and is 11.2 percent of the whole fruit by weight. The fruit and the kernel are the heaviest among the trees selected in Los Baños. The kernel contains 41.5 percent moisture at harvest and on dry basis contains 74.6 percent fat, 14.0 percent protein and 2.9 percent starch. In 1978, the tree produced 3,567 fruits, a production much lower because the tree has been heavily marcotted in recent years. It responds readily to propagation by marcotting, the branches being ready to be separated in about 55 days. In fact, 5 marcotted trees, now about 14 years old, are growing very well in the orchard.

Correlation studies among the various fruit characters of the pili have shown that fruit weight, length and diameter are positively correlated highly with kernel weight *(13).* Thus, either of these 3 external fruit characters may be used as a basis for preliminary evaluation of a large number of seedling trees. Among these characters, fruit diameter is probably the best basis because it is easier to measure with the use of a ruler or a caliper than fruit weight and it gives a higher correlation with kernel weight than fruit length.

SOIL AND CLIMATIC ADAPTATIONS -

The pili is not exacting in its soil requirements and can thrive well on a wide range of soil types *(12).* For best production, however, soils that are deep, fertile and well drained are ideal *(2,12,30,31).*

The pili seems to be a purely tropical plant *(11)* although it can thrive successfully over a wide range of climatic conditions in the Philippines *(12, 30,31).* It is observed to grow well aside from the Bicol provinces, in Quezon, Laguna, Batangas, Nueva Ecija, Oriental Mindor, Capiz, Negros Occidental, Davao del Sur and perhaps elsewhere. It has been even reported to grow and fruit well in the Mountain Province, indicating that its range of climatic adaptation is much wider than known at present. It grows from sea level up to an elavation of 400 meters *(2,10,12,22,30,31,39).* It can not tolerate the cool period and slight frost of southern Florida *(11,39).* In the Philippines, it also grows successfully in places with distinct wet and dry season *(30,31).* But for best performance, it requires a moist humid climate with evenly distributed rainfall throughout the year *(2,12,22,30,31).*

NURSERY PRACTICES

Nut Selection and Germination

Fully ripe fruits should be collected from outstanding trees. It is advisable to remove the pulp before sowing the nuts because studies have shown that clean nuts germinate earlier with a higher percentage of germination than whole fruits *(19).* The presence of the pulp during germination also attracts ants. Removing the pulp is easy by soaking the newly harvested fruits in tap water until the pulp becomes soft and is readily separated from the nut by hand. Depending on the temperature of the water and the degree of maturity of the fruit, the pulp becomes soft after 24-48 hours of soaking. The nuts are thoroughly washed in water to remove all the slimy material adhering to the shell. It is advisable to discard all the nuts that float in water because they are either empty or have undeveloped endosperm and embryo and thus have poor germination *(19).* The nuts are allowed to dry under shade and never under the sun as this also reduces their viability *(30,31).*

The nuts should be sown immediately because they lose their viability quite rapidly even under ordinary room conditions. They cannot be stored at low temperature (4-13^{o}C) because they lose their viability after 5 days. They may be shipped without moist packing *(53)* but should be sown immediately upon arrival at the destination. Storage studies have shown that seed germination decreases rapidly with the length of storage at room temperature *(19).* Nuts planted immediately after harvest give 98 percent germination while those sown 12 weeks later have only 19 percent germination. They completely lose their viability in about 137 days *(8).*

The seeds have a long dormancy that brings about a marked delay in their germination *(1,12)*. This is mainly due to the thick and hard shell which impedes gas exchange and water absorption *(1,28)*. Efforts to shorten or break this dormancy by cracking or removing the shell have not been encouraging because although these practices hasten germination, the percentage germination is greatly reduced *(1,8,11,39)*.

It has been observed that water enters the pili seed through the basal end of the shell where the weakest and thinnest portion is located and which surrounds the functional locule *(28)*. This points to the possibility of cutting the shell a few millimeters at its basal end in order to facilitate the entrance of water into the seed. However, great care should be exercised in cutting off the shell because the radicle is located at this end, and if the cut is made too far, injury to the seed within will surely result.

The nuts are germinated in seedbed using very light porous soil *(49)* such as sand or an equal mixture of sand and garden soil *(12)*. They are laid flat no more than 2 cm deep and at a distance of 15-18 cm between rows and 8-10 cm between nuts in the row *(30,31)*. They may also be sown directly in individual containers, thus eliminating the expense in transplanting. On the average, they will germinate within 30-40 days after sowing *(2,11,22, 42)*.

Seedlings started in the seedbed are transplated in containers (polybags, cans, pots) using preferably an equal mixture of sand, garden soil and compost *(12)*. Transplanting may be done at the cotyledonary-leaf stage or when the first pair of leaves has matured. The seedlings are watered regularly, given a small dose of inorganic nitrogenous fertilizer, and sprayed with insecticide or fungicide as the needs arise. They are transplated in the field when they are about 1 year old *(12)* or about 50-70 cm tall *(30,31)*.

Propagation

The pili may be propagated by seeds, budding, grafting, marcotting and inarching *(2,8,11,12,22,24,30,31,39)*. Almost all of the pili trees found throughout the country have been grown from seeds *(12)*. It is not advisable to use seeds or seedlings as planting materials because, as earlier discussed, the pili does not breed true from seeds *(12,17,26)*. However, because of the absence of a more practical and reliable method of asexual propagation, the use of seeds will have to be resorted to in more years to come. For this purpose, the seeds for planting should be obtained from previously selected outstanding trees.

Marcotting has shown some degree of success *(12,17,18)* but it is a very slow process in terms of the number of planting materials that can be produced from 1 tree. It is reported that young pili stems have internal phloem and as long as this is functional, ringing would not be an effective means of controlling the carbohydrate supply of branches *(11)*.

It has been observed that individual seedling trees differ in their rooting response to marcotting *(12,17,18,43)*. Some trees are easily marcotted while others are less responsive. It is therefore necessary to test the rooting response of every outstanding tree. For trees that respond to marcotting, rooting takes place in 54-150 days (Table 15.3). Larger branches (3-4 cm in diameter) produce roots earlier, produce more roots, and have better survival than smaller branches.

Table 15.3. Number of pili branches rooted, days to root penetration, mean number of roots per marcot and number of living marcots *(8,17)*.

Tree Number	Branch Size (cm)	Number Rooted*	Days to Rooting	Mean Root Number	Number of Living Marcots
28	1	3	150	62	0
	2	5	135	60	0
	3	4	100	91	2
	4	5	104	92	3
51	1	4	54	65	0
	2	5	54	91	0
	3	5	54	120	3
	4	5	54	196	4

*Based on 5 branches.

Anatomical investigations have shown that there are no differences in the stems of easy-to-root and difficult-to-root pili trees *(43)*. Two weeks after ringing, initial callus formation occurs in both stems. Callus originates from the vascular bundle. More callus formation takes place up to the fifth week. At this time, vascular elements differentiate at the periphery of the callus distal to the wood portion. This vascular element differentiation is contiguous with the vascular elements of the stem portion not disturbed by callus formation. In the sixth to the eight week, roots start to form in some stems of easy-to-root trees by piercing through the callus. No such root formation occurs on difficult-to-root trees. The inability of these trees to produce roots is not due to anatomical barriers but may be due to rooting factors such as imbalance in rooting hormone that inhibits root initiation. It is therefore possible to make these trees respond to marcotting by external application of rooting-forming hormones such as indolebutyric acid.

It has been reported that the pili may be propagated by other asexual methods such as grafting and budding on pisa seedlings *(2,22,23,51)* using non-petioled, slender, rather smooth, brownish green scions. For budding, the buds are cut 4-5.5 cm long and inserted in the stock at a point where the

bark has approximately the same appearance as the scion. In cleft grafting, non-petioled scions, 8-10 cm long and 8-10 mm in diameter, are inserted in the stock of nearly the same age and size. Results of these propagation techniques are still very limited and may not be recommended for propagating the pili in commercial scale *(12)*.

It has also been suggested that the pili might possibly be propagated by stem cutting *(54)*. This is born out by the observation that during the rainy period, some trees freely develop aerial roots on their trunk. It is also suggested that mature wood is more likely to root than young wood.

In efforts to multiply selected outstanding pili trees, the U.P. at Los Baños Institute of Plant Breeding started May, 1979 to investigate the response of the promising pili trees to various asexual propagation methods. Preliminary results have confirmed previous findings on marcotting. Some degree of success has been obtained with cleft grafting and inarching but these methods need to be further investigated. One problem with cleft grafting is that the diameter of the shoots of many promising trees is much too big to match the size of 1-year-old seedling rootstocks. Experiments on stem cutting and budding are also underway.

CULTURAL PRACTICES

As previously discussed, the existing pili trees are found mostly under forest conditions or as components of the traditional mixed planting operations in the backyards. Under these conditions they are grown with very little regard to some system of cultural management. There is, therefore, very little information available regarding the cultural requirements of the pili. This meager information is supplemented with standard orchard practices to arrive at interim recommendations for pili orchard management.

Land Preparation

For planting in the backyards or along the roads and avenues, no elaborate land preparation is needed. Planting holes are dug just wide and deep enough to give ample room of the ball of soil that goes with the planting material. A very large hole is not necessary as this may only serve as a water trap especially for heavy-textured soils. Where second growth forests are to be utilized, it is necessary to cut down all the existing trees and shrubs and preferably, to remove all the stumps also. Holes are dug as in backyard planting at the desired planting distance and the holes should be aligned as much as possible in all directions.

Where the land is open and has been previously utilized for other crops, land preparation follows the standard system. This involves deep plowing to expose and loosen the soil followed by several harrowings until the desired soil tilth is attained. This is done well in advance of planting to thoroughly expose the soil. Stakes are set at the desired planting distance and holes are

prepared at the positions previously occupied by the stakes.

Planting

With the present system of planting pili, too often the trees are very closely planted with other plant species so that they tend to grow into very tall trees with few lateral branches. As a result, harvesting of fruits becomes a very difficult operation.

As an orchard crop, the pili should be given ample space for full development. Seedlings should be planted at least 12-16 m apart *(2,22,30,31)* because of their natural tendency to grow into large trees. With ample spacing, the trees would form a compact canopy and branching will be closer to the ground. Marcotted plants would be expected to grow much smaller and may be spaced about 8-10 m apart. For other asexually propagated plants, a spacing of 10-12 m may suffice *(30,81)*.

Since the pili is a dioecious species and it is expected that about half of the seedlings will turn out to be male trees, it is suggested that for each tree position, 2 seedlings are to be planted 30-50 cm apart. When the trees start to flower at which time their sex would be identified, all male trees are cut down leaving only a few to serve as pollen source. For asexually propagated planting materials, it is also necessary to interplant male trees especially when the planting is quite isolated *(12)*. A ratio of 1 male to every 20-25 female trees may be adequate.

Planting may be done anytime of the year provided that sufficient water can always be made available to the plants. Ideally however, setting of plants in the field should be done at the onset of the rainy season to eliminate the need for irrigation while the plants are still establishing in the soil *(30,31)*. Before planting, the leaves are pruned in halves and the containers that go with the planting materials should be carefully removed. The plants are carefully set in the holes and the remaining space is filled with top soil and pressed down to remove large air spaces. The plants are watered soon after planting and provided with shade.

Irrigation

Limited experience shows that the first dry season is very critical for the successful establishment of the pili plants. It is, therefore, necessary to irrigate the plants and to maintain the shade to reduce transpiration and desiccation of the leaves. If the area is not fenced, it is also advisable to protect the plants against stray animals. During the succeeding years, the shade may be dispensed with and irrigation may no longer be necessary. It is a good practice, however, to irrigate during the prolonged dry seasons.

Fertilization

While no information is available regarding the fertilizer requirements of the pili, the trees would certainly benefit from fertilization. As a general recommendation, 1-year-old plants are fertilized with 100-200 g of nitrogen-containing materials. This amount should be increased gradually every year until the first flowering and fruiting season when each tree should be given about 500 g of complete fertilizer high in nitrogen and potassium. As the trees grow bigger and as production increases, the amount of fertilizer should be increased correspondingly. A full bearing tree should receive at least 2 kg of complete fertilizer. Other fertilizer elements should be supplied as indicated by soil analysis.

To be fully and readily utilized by the plants, the fertilizer should be applied when there is sufficient moisture in the soil and where the greatest root concentration is located. As a general recommendation, half of the amount should be applied at the onset and the other half toward the end of the rainy season. The fertilizer may be applied in a ring around the trunk or in small holes well distributed beneath the canopy.

Training and Pruning

The first operation is the cutting down of unwanted male trees in the orchard. Since given ample space, the plants will develop well-shaped branches, training should be limited to the removal of excess growth during the formative years and maintaining 2 or 3 main branches after which no further training is necessary. If the plants tend to grow tall without developing lateral branches, they may have to be cut back 1 m from the ground to induce branching. This should be done during the second year. For bearing trees, pruning is minimal and should be limited to the removal of dead branches.

Intercropping

The land should be fully utilized while the pili trees are still not productive. This may be done by planting small fruit crops such as banana, papaya and pineapple, or other annual field and vegetable crops that are adapted in the area. Intercropping should be stopped when the trees start to close in or when such practice interferes with orchard operations. When it is no longer feasible to grow intercrops, the orchard should be grown to a leguminous cover crop such as Centrosema, Pueraria or Calopogonium.

Control of Pests and Diseases

Insect pests do not seem to be a serious problem on pili *(29,30,31).* This is probably because of the resinous material in the plant. The ripening

fruits are often coated with algal growth but apart from marring the appearance of the skin, this does not affect the pulp or the kernel at all. A certain borer has been found on fallen immature fruits in Bicol *(29,30,31)* but the severity of this pest has not been considered. Young leaves of seedlings have been observed to be attacked by anthracnose but this is easily controlled by spraying with a fungicide.

Harvesting and Yield

It is claimed that the pili is a very slow growing and maturing plant *(48)*. Seedling trees will, on the average, start producing fruits 5-6 years after planting *(2,22)* although trees that produce fruits after the second or third year have been reported. An economic yield may be expected during the 10th year *(48)*. Marcotted and grafted trees have been observed to bear fruits after 2 or 3 years and economic yield may be expected during the fifth or sixth year.

Many seedling trees produce fruits over a long period but the main duration of harvest is from May to October *(2,22)* with peak in June to August *(20,26)*.

The fruits on a tree do not ripen at the same time. Only well ripened fruits should be harvested *(30,31)* although in actual practice, since climbing the tree is difficult, all fruits that show various shades of purple are harvested. This probably contributes to the poor storage and shelf-life of the raw nuts and processed kernels. Harvesting is usually done by 2 men, 1 climbing the tree and the other collecting the fallen fruits. Both operations may be done by 1 person although much more slowly. Picking is done with a bamboo pole 3-4 m long with a wire hooked at the tip. The harvested fruits are placed in baskets or sacks and brought to the house for processing.

The yield of seedling trees varies considerably. At 10 years old, the average yield per tree is estimated to be about 8-10 kg clean, dried nuts *(48)*. The yield of full grown trees may vary from 30-1,000 kg with exceptionally large, productive trees yielding as much as 5,000 kg. An average yield of 100-150 kg clean nuts is a conservative estimate and it may be considerably higher *(48)*. An actual count of fruits from a 45-year-old tree at Banao, Guinobatan, Albay, shows 10,000 fruits, producing 83 kg of air-dried nuts *(29)*.

PROCESSING

Processing of the pili fruits involves the following steps: pulp removal, nut drying, storage and extraction of kernel.

Pulp Removal

In the early years of the pili industry the harvested fruits were simply piled in a heap under the shade of a tree until the pulp softened and was

easily removed by hand. In recent years, however, 2 methods of pulp removal have been practiced: hot water treatment and retting *(4,20,29,30, 31,48)*. In the first method, water is heated in a large vat until it is hot enough to scald the hand. The newly harvested fruits are put in the vat and the water is kept hot and stirred once in a while to keep its temperature uniform. The fruits are left in the water until the pulp becomes soft and is easily peeled off by the hand. They are removed from the water, cooled and the pulp is peeled off at once. It is claimed that if the fruits are left too long in the hot water, the pulp shrinks and becomes difficult to peel.

The other method of pulp removal involves soaking the fruits in tap water until the pulp becomes soft. The fruits do not soften at the same time but on the average all the fruits can be worked on in 2-3 days. In both methods, the nuts are thoroughly washed with water to remove the slimy material adhering to the shell. All nuts that float in water are discarded.

Pulp removal studies have shown that soaking the fruits in water at 40-50°C is most practical because it is faster and the nuts remain in good condition for about a year or longer *(4)*. Below this temperature, as in retting, it takes longer (about 21 hours) to soften the pulp. Above this temperature, the pulp becomes soft in a much shorter time but the nuts also become rancid much faster. At high temperature, there is an optimum time at which the pulp can be removed easily. With longer soaking at the same temperature, the pulp becomes so hard that it can be removed only with difficulty. This confirms the previous experience of pili growers.

Drying

After cleaning, the kernels may be extracted from the shell and this is usually practiced during the beginning of the harvest season when there is no more supply of nuts from the previous harvest. Newly harvested nuts, however, have their kernels sticking to the shell *(44)*. When the nuts are cut open, the kernels are tight in the cavity and when separated from the shell are usually damaged. In actual practice, therefore, the nuts are first dried under the sun for 2-3 days when the kernel shrinks for easier shelling.

In the laboratory, the nuts may be dried to an optimum moisture content of 3-5 percent by ovendrying *(44)*. It requires about 27-28 hours to dry the nuts at 30°C, 14-15 hours at 50°C and 12-13 hours at 60°C. The first temperature is more or less equivalent to sundrying. Kernels dried at this temperature range retain their desirable qualities. They are milky white, not oil-soaked and have a pleasant flavor.

Storage

After drying, the nuts are stored in sacks or piled in a heap in or under the house *(20)*. Studies have shown that the optimum moisture content for

storage of pili nuts lies between 2.5-4.6 percent at which moisture level the nuts are at equilibrium with surrounding air at room temperature *(44)*. At lower moisture content, the kernels may become susceptible to rancidity and at higher moisture level, they may become susceptible to mold attack and unfavorable enzymatic reactions.

Decortication

Extraction of the kernel is at present a purely manual operation. The worker cuts the shell with the use of a special bolo crosswise at the middle portion. Great skill is required because the stroke should be controlled in such a way that it does not cut through the kernel. A skilled worker can shell 2 sacks of nuts a day. After cutting the shell, the kernel is separated easily.

Removal of Seedcoat

The brown seedcoat also sticks very tightly to the kernel during drying. To peel off the testa, the kernels are soaked in water until it slips readily when the kernel is squeezed with the fingers. A much faster way to do this is to blanch the kernels in boiling water for about 3 minutes and then the kernels are cooled in water *(44)*. The clean kernels are then ready for processing.

USES AND FOOD VALUE

Tree. The pili is a plant of many uses. The tree itself is a handsome, attractive evergreen. Its symmetrical branches make the pili an excellent avenue and border tree and a verdant shade tree in the lawn *(12,26,30,31)*. It is also very resistant to strong winds *(26)*, thus making it an excellent windbreak. The young shoots may be used in salads *(26)*. The wood is rich in resin and makes good firewood *(26,30,31)*. The bark is also a source of resin *(47)*.

Pulp. When boiled, the pulp is edible when seasoned with salt, pepper or fish sauce *(6,11,12,22,24,29,46,47,48)*, and is considered a nutritious food item by some people in the Bicol region *(26)*. It resembles sweet potato in texture and appearance but is rather tasteless and insipid *(48)*. It may be made into a spread *(21)*. Table 15.4 shows the chemical composition of the pulp on fresh and dry weight basis. The pulp which is about 64.5 percent of the whole fruit by weight has the same food value as avocado *(35)*.

The pulp also contains oil and Table 15.5 shows its chemical composition and constants. In Bicol, this oil is occasionally extracted and used for cooking and lighting *(6,12,24,26,46,47)*. It has a similar composition as the kernel oil and is brilliantly clear and greenish yellow *(35)*. It is suitable com-

Table 15.4. Composition of pili pulp *(35)*.

Component	Fresh Weight	Dry Weight
	per 100 g	
Moisture, %	72.8	–
Protein, g	2.9	8.0
Fats, g	12.4	33.6
Crude fiber, g	1.3	3.4
Ash, g	3.4	9.2
Carbohydrates, g	7.2	45.8
Food energy, cal	156.3	533.1

Table 15.5. Composition and constants of pili pulp oil *(35)*.

Component		Constants	
Oleic glycerides	56.7%	Specific gravity (30°C)	0.9053
Linoleic glycerides	13.5%	Refractive index	1.4722
Saturated acids	29.3%	Saponification number	194.1
Unsaponifiable matter	0.5%	Iodine number (Hanus)	72.2
		Thiacynanogen value	61.0

mercially for the manufacture of edible products and soaps and for other purposes for which cottonseed oil is used *(35)*.

One less explored commercial use of the green pulp is the making of pickle. It has been reported that while all stages of fruit development can be pickled, the green stage soon after the shell hardens but before the pulp becomes too fibrous is the best stage *(36)*.

Shell. The hard, stony shell of the pili fruit makes excellent fuel *(12,26,30, 31)* and possibly a good component of the growing medium for orchids and anthuriums. When well polished and neatly varnished, the shell makes an attractive keyholder like that made from pitogo and palomaria *(12)*. In Indonesia, attractive ornaments which are very popular among tourists are fashioned out of the shells of other *Canarium* species *(12,26)*. In industry, the use of pili shell for making charcoal has yet to be explored.

Testa. The covering of the seed is just thrown away but once its chemical composition is known, it may find some uses in industry.

Kernel. From an economic point of view, the kernel is the most important part of the pili fruit. Table 15.6 shows the chemical composition of the pili kernels as reported by several authors *(5,16,24,27,41)* and Table 15.7 shows their mineral and vitamin contents *(27)*. Pili kernels are rich in fats, protein, food energy, calcium, phosphorous and potassium. The Filipino diet may be markedly improved with the general use of pili kernel as a component *(30,31)*.

The kernel, whether eaten raw or roasted, is crispy and has a delicious flavor *(6,12,22,24,38,46)*. Roasted kernel may be served in the same manner as almond and is considered by many to be superior to it *(6,24,34,46)*. It is used commercially in the manufacture of various confectionary products *(6,12,24,46)*. It is also used as a flavoring for ice cream. Roasted pili kernel is sometimes used to adulterate chocolate *(6,24)*. It also makes a good preserve when cooked in syrup *(22,24)*. Uncooked kernel is claimed to have some purgative property *(6,24)*.

Tables 15.8 and 15.9 show the constants and chemical composition of the pili kernel oil which indicate that it is composed almost entirely of the glycerides of oleic and palmitic acids *(46)*. The oil is light yellow, has an agreeable odor and taste, and is suitable for culinary purposes *(6,12,24,38,46)*. It has a very good keeping quality *(30,31)* and may be stored for about 6 months without producing any rancid odor or taste *(46)*.

PROCESSING

The pili pulp and kernel may be made into several acceptable products. A processor in Guinobatan, Albay, for example, manufactures 10 food items out of the pili kernel. These are plain roasted kernels with or without testa, fried and salted, sugar-coated (white), sugar-coated (glazed), pudding, "molido," "mazapan de pili", "pili turron", and sugar-coated with sesame seeds. The preparation of some of these products is described below:

Pulp spread. The fruits are soaked in water at 40-45°C for 25 minutes to soften the pulp. The softened pulp is removed from the nut and blended until the resulting puree is uniform and finely divided. The blended pulp is mixed with cococream. Based on sensory and taste tests, a mixture of 1 cup pulp and 7 tablespoons cococream is the most acceptable. The pulp-cococream mixture is mixed with 1 cup sugar and 9 tablespoons cocomilk. The whole mixture is blended for about 3 minutes to avoid lumping of pulp after which it is cooked over a low fire for 5-10 minutes and flavored with 3/4 tablespoon vanilla. The cooked mixture is poured into a sterilized jar at about 90°C and sealed with paraffin and covered. The resulting spread has glossy brown color and slight pili odor. It can easily be spread and has a taste that is a moderate combination of sweetness and pili flavor *(21)*.

Candies. Whole or halved kernels are cooked in brown sugar (glazed) or refined sugar (white) until they are fully coated. The finished product is cooled and placed in plastic jars, covered and sealed *(29)*.

Table 15.6. Proximate analysis of pili kernels *(5,16,24,27,41)*.

Component	Brill & Agcaoili (1915)		Coronel & Zuño (1979)		Garcia (1941)		Intengan et al. (1968)	Padilla & Soliven (1933)
	Long Fruit	Short Fruit	Range	Mean	Range	Mean		
Edible portion, %	–	–	4.40–16.61	10.71	–	–	16.0	15.82
Moisture, %	2.79	2.90	35.6 –51.4	41.6	11.08–35.06	23.74	8.9	4.16
Food energy, cal	–	–	–	–	–	–	645.0	–
Protein, %	12.06	11.83	11.5 –15.7	13.9	12.06–16.42	13.91	14.2	16.53
Fat, %	74.39	72.53	69.2 –76.6	73.1	74.79–83.62	78.55	68.5	72.01
Total carbohydrates, %	–	–	–	–	–	–	5.5	4.31
Sucrose, %	0.85	0.66	–	–	–	–	–	–
Reducing sugars, %	0.45	1.35	–	–	–	–	–	–
Starch, %	4.33	5.11	2.59– 4.32	3.26	–	–	–	–
Crude fiber, %	2.15	2.42	–	–	0.83– 4.67	1.86	3.2	–
Ash, %	2.97	3.15	–	–	2.79– 3.52	3.11	2.9	2.99

Table 15.7. Mineral and vitamin contents per 100 g of pili kernels *(27)*.

Mineral	Quantity	Vitamin	Quantity
Calcium, mg	119	Vitamin A, I.U.	45
Phosphorus, mg	508	Thiamine, mg	0.95
Iron, mg	2.6	Riboflavin, mg	0.12
Sodium, mg	3	Niacin, mg	0.4
Potassium, mg	489	Vitamin C, mg	Trace

Table 15.8. Composition of pili kernel oil *(46)*.

Component	Quantity (%)
Oleic glycerides	59.6
Palmitic glycerides	38.2
Stearic glycerides	1.8
Unsaponifiable matter	0.2

"Turron". Cooked sweet potato is peeled and mixed with 300 pili kernels and the mixture is ground with 1 spoonful of sesame seed. One small can condensed milk is mixed with 9 beaten eggs and the mixture is added to the ground pili and sweet potato. One kilo sugar is melted and cooked for about 25 minutes after which the whole mixture is added. One teaspoon vanilla is added for flavoring. The whole mixture is cooked further until the desired consistency is attained. The mixture is cooled and cut to desired forms *(29)*.

Another method of preparing pili paste is described as follows: Pili kernel is toasted until light brown and ground. A cup of ground kernel is added into a thick syrup prepared by boiling 2 cups sugar and 1 cup water. To the mixture is added 1 tablespoon vanilla and a little amount of salt. Cooking is continued until a little amount hardens when dropped in a saucer of water. A centimeter thick of the cooked mixture is poured on sugared board and dried in a warm breeze or in a warm oven. The paste is cut into squares, rolled in granulated sugar and wrapped in wax paper *(40)*.

Pudding. Two cups mashed sweet potato are added to 2 cups ground kernels, 1-1/2 cups refined sugar, 3 tablespoons butter, 1/2 cup condensed milk, and 3 beaten eggs. The mixture is stirred until smooth and to it is added 1 teaspoon vanilla. The mixture is poured into small rectangular paper boxes and baked in an oven with moderate heat until the color is light brown *(29)*.

Jelly roll. One cup mashed squash, 1/2 cup ground pili kernels, 1/2 cup evaporated milk and ½ cup refined sugar are mixed. The whole mixture is

cooked with constant stirring until fine and smooth. The cooked mixture is removed from fire and to it is added one teaspoon vanilla *(29)*.

PACKAGING

Roasted, fried and sugar-coated kernels are usually packed in plastic bottles. Since they are not packed in vacuum, the processed products last for only a few months. Moreover, during hot weather, the plastic material reacts with the oil producing an unpleasant odor. Studies on packaging pili products are needed to prolong the shelf-life of pili. Tins as packaging materials offer many advantages especially if the pili products are intended for export.

The pili is usually marketed as dried nuts or shelled kernels. *(20)*. Prices are usually low during the harvest season (May to July) and high during the rest of the year with peak in December *(3)*. The current price in 1982 is P2.60 per kilo of dried nuts and P30 per kilo of shelled kernels.

Chinese merchants are active buyers in local markets *(20)*. Together with other middlemen they control the price of nuts the whole year round *(3)*. These Chinese merchants also export raw nuts to Hongkong and Taiwan, thus draining the supply of raw nuts which cannot now even meet the demands of local processors.

MANILA ELEMI

The term elemi applies to a variety of resinous products obtained from various plants *(34)*. The greater bulk of the world's supply comes from the Philippines and is known as Manila elemi *(12)*. The plant species that produce elemi all belong to the family Burseraceae. The most important of these species in terms of resin yield is pisa, *C. luzonicum (12, 34)*. The elemi is tapped from the trunk and is known locally by the Spanish term *brea blanca* meaning white pitch *(12, 34)*.

Pisa grows abundantly at low and medium altitudes in the primary forests of Luzon, Masbate and Samar *(34)*. It is mostly in Quezon, principally from the towns of Gumaca, Calauag and Lopez, that tapping for elemi is done. Tapping begins in the early part of July or as the new leaves become green and mature and continues until March when the trees shed their leaves. The length of the tapping season is, therefore, about 9 months.

When the bark is cut, the resin oozes out. At first it is always soft and has a very fragrant odor but on standing it gradually loses its volatile constituents (elemi oil) and hardens. The resin accumulates in large masses when it is collected. A young tree 15 cm in diameter yields an average of 2 kg. of resin per month, that 60 cm in diameter yields 60 kg, and that 1 m in diameter, 120 kg or more.

Table 15.10 shows that the pisa resin consists principally of resenes together with some resin acids and volatile terpenes *(34)*. By steam dis-

tillation, the volatile terpene oil passes over to the distillate, leaving a residue of resenes and other elemi constituents. The resenes are very resistant to the action of alkalis and other common chemical reagents (petroleum, alcohols, ketones) but soluble in coal tar. Elemi is compatible with vegetable, fish and animal oils, waxes, stearic acid and cellulose derivatives.

Table 15.10. Composition and constants of Manila elemi *(34)*.

Constituents		Constants	
Insoluble matter, %	0.35– 1.00	Saponification number	28.53
Terpenes		Acid number	18.50
Volatile, %	17.40–25.21	Ester number	10.03
Nonvolatile, %	1.07– 2.08		
Resenes, etc., %	55.50–61.44		
Resin Acids, %	15.33–18.00		
Moisture, %	1.25– 2.75		

In pharmacy, the elemi is used as an ingredient of plasters and ointments *(34)*. In industry, it is a valuable material for the manufacture of adhesives, cement wax compositions, printing inks, linoleum, fire proofing and water proofing composition, paints, varnishes, plastic and asphalts. It is also used in engraving and lithography.

The Philippines exports Manila elemi to the United States, Great Britain, France, Germany, Italy, Netherlands, Cuba, China, Hongkong and Japan in fairly large quantity *(30, 31)*. One local company exports 5-10 t of Manila Gum Elemi No. 1 (white) from July to February. This export grade elemi is of pasty consistency, gravy to yellowish white, soft and balsam-like. It is packed in thick polyethylene plastic bags and crated in a wooden box of 40-kg net weight.

REFERENCES

1. Adriano, M.S. 1977. Germination of chemically treated and mechanically scarified chico and pili seeds. B.S.A. thesis, Coll. Agric., U.P. Los Baños, Laguna.
2. Anonymous. 1954. How to raise mangosteen, pili, pineapple, and mango. Filip. Farm. 1:31-32.
3. Anonymous. 1978. Pili has gone a long way. Times J. (January 26), p. 14. Manila.

4. Austria, P.L. 1932. Certain studies on the removal of husks of pili nuts (*Canarium ovatum* Engl. and *C. luzonicum* (Blume) A. Gray). Philip. Agric. 20:659-668.
5. Brill, H.C. and F. Agcaoili. 1915. The Philippine oil-bearing seeds and their properties. Philip. J. Sci. A10:105-121.
6. Brown, W.H. 1954. Useful plants of the Philippines. Rep. Philip. Dep. Agric. Nat. Res. Tech. Bull. 10. Vol. 2 Bur. Printing, Manila.
7. Bureau of Agricultural Economics, Ministry of Agriculture. 1977. Crop statistics. Philippines.
8. Cabrera, D.V. 1932. Some methods of propagation of pili (*Canarium ovatum* Engl. and *Canarium luzonicum* (Blume) A. Gray). B.S.A. thesis, U.P. Coll. Agric., Laguna.
9. Central Bank. 1977. Foreign Trade Statistics of the Philippines. NEDA/NCSO, Manila.
10. Chana, S.S. and P.V. Savant. 1979. Vegetative propagation of cashew by bud grafting in Goa. Indian Farm. 28:21, 23-24.
11. Chandler, W.H. 1958. Evergreen orchards. Lea and Febiger, Philadelphia.
12. Coronel, R.E. 1966. Let us save our pili industry. Philip. Farms Gard. 3(12):16-17, 28.
13. Coronel, R.E. and J.C. Zuño. 1980. Note: The Correlation between some fruit characters in pili. Philip. Agric. 63:163-165.
14. Coronel, R.E. 1978. The fruit crops of the future. Proc. First Nat. Fruit Sympo., pp. 46-52. PCARR, Laguna.
15. Coronel, R.E. and J.C. Zuño. 1979. Fruit crops in the Philippines: a systematic list. Inst. Plant Breed. Bull. 1. Coll. Agric., U.P. Los Baños, Laguna.
16. Coronel, R.E. and J.C. Zuño. 1980. Note: Evaluation of fruit characters of some pili seedling trees in Calauan and Los Baños, Laguna. Philip. Agric. 63:166-173.
17. Coronel, R.E., L.O. Bondoc and N.C. Dacanay. 1972. Propagating pili by air layering. Unpublished.
18. Dacanay, N.C. 1968. Influence of the size of branches on the marcotting of pili (*Canarium ovatum* Engl.). B.S.A. thesis, U.P. Coll. Agric., Laguna.
19. Dalisay, A.R. 1961. A preliminary study on the germination and storage life of pili nuts. B.S.A. thesis, U.P. Coll. Agric., Laguna.
20. Despi, E.D. 1965. Marketing of pili nut on the farm level in selected barrios in Sorsogon. B.S.A. thesis, U.P. Coll. Agric., Laguna.
21. Dipad, M.D. 1979. Development of pili pulp spread. B.S.F.T. thesis, U.P. Diliman.
22. Galang, F.G. 1955. Fruit and nut growing in the Philippines. AIA Printing Press, Malabon, Rizal.

23. Galang, F.G. and A.R. Elayda. 1924. Experiments on vegetative propagation of tropical fruits at the Lamao Experiment Station, Lamao, Bataan. Philip. Agric. Rev. 17(3):203-205.
24. Garcia, G.M. 1941. A comparative study of nutrients of pili (*Canarium ovatum* Engl.). Philip. Agric. 30:96-106.
25. Gonzalez, L.G. 1934. Outstanding results of agronomic and horticultural research: Fruits. Philip. Agric. 23(6):387-393.
26. Gonzalez, L.G. and J.C. Bunoan, Jr. 1947. Variability of pili trees grown in the College of Agriculture. Philip. Agric. 31:60-65.
27. Intengan, C.L. et al. 1968. Food composition table recommended for use in the Philippines. Food Nut. Res. Inst. Handb. 1. Nat. Sci. Dev. Board, Manila.
28. Juliano, J.B. 1937. The stony layer of pili. Philip. Agric. 25:639-654.
29. Lanuza, E.A. 1939. The pili nut in the Bicol region. Philip. J. Agric. 10:21-23.
30. Lanuza, E.A. 1948. Pili culture. Plant indus. Dig. 11:21-27.
31. Lanuza, E.A. 1969-1970. Pili culture. Plant Indus. Dig. 32-33:7-11.
32. Li, H.L. 1970. The origin of cultivated plants in Southeast Asia. Econ. Bot. 24:3-19.
33. Linsangan, E.S., R.E. Coronel and F.N. Rivera. 1979. Floral morphology and fruit set of pili. Philip. Agric. 62:219-225.
34. Manalo, G.D. and A.P. West. 1940. Analysis and composition of Manila elem. Philip. J. Sci. 78(1):111-120.
35. Marañon, L.T., A.D. Cruz and A.M. Tuazon. 1954. Composition of pili pulp and pili pulp oil from the fruit of *Canarium ovatum.* Philip J. Sci. 83(4):359-363.
36. Mercado, H. 1942. A study of the suitability of pili fruits for pickling purposes. B.S.A. thesis, U.P. Coll. Agric., Laguna.
37. Merrill, E.D. 1912. A flora of Manila,. Bur. Printing, Manila.
38. Monsaiud, M.R., A.L. Tongacan, F.R. Lopez and M.Q. Lagrimas. 1966. Edible wild plants in Philippine forests. Philip. J. Sci. 95(4): 431-561.
39. Mortensen, E. And E.T. Bullard. 1964. Handbook of tropical and subtropical horticulture. Dep. State, Agen. Int. Dev., Washington, D.C.
40. Oñate, L.U. 1967. Preserving fruits. Coll. Agric. Farm Bull. 23. UP Coll. Agric., Laguna.
41. Padilla, S.P. and F.A. Soliven. 1933. Chemical analysis for possible sources of oils of forty-five species of oil-bearing seeds. Philip. Agric. 22:408-415.
42. Padolina, F. 1931. Vegetative propagation experiments and seed germination. Philip. J. Agric. 2(4):347-355.
43. Tuazon, V.A. 1978. Anatomical study of rooting during marcotting of pili (*Canarium ovatum* Engl.). B.S.A. thesis, U.P. Los Baños, Laguna.

44. Villamor, C.A. 1979. Comparison of storage characteristics of ripe shelled pili (*Canarium ovatum*) kernels dried to three levels of moisture. B.S.F.T. thesis, U.P. Diliman.
45. Villegas, V.N. and R.E. Coronel. 1980. Cytology of Philippine fruits. 1. Pili (*Canarium ovatum* Engl.) and barobo (*Diplodiscus paniculatus* Turcz.). Philip. Agric. 63:174-178.
46. West, A.P. and S. Balce. 1923. The composition of pili-nut oil. Philip. J. Sci. 23(3):269-276.
47. West, A.P. and W.H. Brown. 1920. Philippine resins, gums, seed oils and essential oils. Bur. Forest. Bull. 20.
48. Wester, P.J. 1915. New or noteworthy tropical fruits in the Philippines. Philip. Agric. Rev. 8:103-114.
49. Wester, P.J. 1916. The germination of seed of *Canarium.* Philip. Agric. Rev. 9(2):155-160.
50. Wester, P.J. 1916. Food plants of the Philippines. II. Fruits and spices. Philip. Agric. Rev. 9:199-256.
51. Wester, P.J. 1917. Additional data with reference to vegetative propagation of tropical fruits. Philip. Agric. Rev. 10:92-95.
52. Wester, P.J. 1921. The food plants of the Philippines. Philip. Agric. Rev. 14(3):211-384.
53. Wester, P.J. 1924. The preparation and packing of seeds and scions of trees and shrubs in the tropics. Philip. Agric. Rev. (17)(1): 46-51.
54. Wester, P.J. 1929. Observations on agriculture in the Philippines. Phil. Agric. Rev. 22(3):205-233.
55. Wester, P.J. and O.W. Barrett. 1912. Annotated list of Philippine fruits. Philip. Agric. Rev. 5:365-370.
56. Zuño, J.C. and R.E. Coronel. 1982. Sex distribution in pili and morphology and biology of flowers from hermaphrodite trees. Philip. Agric. In press.