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Bilimbi

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Averrhoa bilimbi L.
Family: Oxalidaceae

Bilimbi can reach 50 feet in height but is usually kept shorter to facilitate harvesting. Heavy pruning can suppress flowering. The tree forms 18–64 flowers in panicles that form on the trunk and older branches. The waxy, pale green fruit is slightly lobed, about 4 inches long and up to an inch wide. Seeds are about ½ inch long. The sour fruit changes from green to light yellow when ripe. It matures 50–60 days after flowering. The tree is tropical and extremely sensitive to cold and wind.

Other common names

bilimbi, cucumber tree, tree sorrel, pickle tree (English); kamias, camias, pias (Philippines); ta ling pling (Thai); huang gua shu (Chinese); belimbing buluh, blimbing asam (Malaysia); bilimbim, biri-biri, limao de caiena, azedinha (Brazil); vilimbipuli, irumpanpuli (in Malayalam); khe tay (Vietnamese); taling pling (Thailand); bilimbi (India).

Origin

Bilimbi is closely related to *Averrhoa carambola* (carambola, starfruit). It originated in Southeast Asia and is claimed as a native by Malaysia and the Indonesian Moluccas. The fruit was taken from Timor to Jamaica in 1793, supposedly in Captain William Bligh's second breadfruit voyage, and was distributed widely in the New World. It may have to come to Hawai'i with the first immigrants from the Philippines in 1906. In 1815, "almost-sweet" forms of the fruit were first found in the Philippines, but sour forms were preferred. Some of these almost-sweet forms are still found in the Philippines but have not been found in Hawai'i.

The tree is cultivated throughout Indonesia, Malaysia, the Philippines, India, and Sri Lanka on a small scale and is frequently found as a backyard tree. It is also common in other Southeast and South Asian countries and is now found worldwide. Members of the *Oxalidaceae* are primarily herbaceous, often with tubers and bulbs. There are some shrubs in the family and only two woody genera, of which *Averrhoa* is one. The genus is named after the 12th-century Moorish physician and philosopher Averroës (ibn Rushd) from Cordoba, Spain. *Averrhoa bilimbi* L. and *A. carambola* L. are the only two species of interest, because of their fruit.

Cultivars

Both sweet and sour types have been reported in the Philippines, although no named cultivars are known to exist. Further trials of the sweeter types are indicated.

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Environment

Depending on rain or the frequency of irrigation, the tree can fruit multiple times a year in Hawai‘i. At other times it fruits once or twice a year for a period of 2 months. The trees thrive in full sun and will grow in most types of soil. The tree has been observed in Hawai‘i up to 3500 ft elevation. Another tree at 300 ft elevation at a South Kona test plot produced fruit year-round with irrigation.

Propagation

Bilimbi usually is propagated by seed, although airlayering and grafting have been successful. Grafting bilimbi onto carambola rootstock (and vice versa) is possible. Topworking trees is also possible.

Culture and management

Where bilimbi is in commercial production, it is generally intercropped with other fruit trees at a distance from 10 x 10 ft to 20 x 20 ft. In Taiwan, 10-10-10 fertilizer is used. Test trees in Hawai‘i were given quarterly applications of 6-6-6. Soil should be checked periodically, especially for manganese, zinc, and iron deficiencies. The trees prefer a pH range of 5.5 to 6.5 in a well-drained soil. Heavy mulching is advised, especially for trees without irrigation and in full sun. Dried and dead braches should be removed, along with watersprouts and root shoots.

Pests and diseases

No serious insect pests are reported. *Fusarium decemcellulare* can cause a serious inflorescence growth disorder. *Penicillium* has been reported as pathogenic to the fruit. *Phyllosticta* sp., *Cercospora* sp., and *Colletotrichum gloeosporioides* might also affect the tree and fruit.

Harvesting and yield

Seedling trees will fruit in 4–6 years. Healthy, well-pruned 10-year-old trees can easily produce 100 pounds of fruit per season. Fruit is picked by hand, either individually or in clusters, when it starts to turn to a lighter green. Fruit is very soft-skinned and should be handled with care. In the field fruits should not be piled more than a few inches on top of one another in the harvest containers.

Postharvest considerations

The fruit has a very short shelf life: up to 4 or 5 days in grocery store produce sections. It should be used as soon as possible after harvest. Shelf life can be lengthened to 7–8 days if the fruit is chilled in the field at time of harvest. The fruit can be dried or frozen for future use.

Packaging, pricing, and marketing

The sour bilimbi has yet to become popular with a large number of consumers, and grocery store sales are very limited in most Hawai‘i markets. The grocery stores that offer bilimbi either sell the fruit in bulk or in small plastic “clamshells.” The chefs that utilize bilimbi order 5-pound clamshell packages. The fruit sells from $2.00 to 3.50 a pound. At farmers’ markets fruit can found in bulk or in small clamshell containers and usually sell for 25¢ each or five for $1.00. Having recipes from chefs available at a Kona farmers’ market helped to increase sales to customers unfamiliar with bilimbi. Juiced and dried fruit can be frozen or preserved for future use.

Nutritive value

Per 100 grams of edible pulp; edible pulp is 86% of fruit weight.

Proximate (g)	
water	92.5–94.7
energy (kcal)	27
protein	0.61
lipid (fat)	0.3
carbohydrate	6.3
fiber	0.6
ash	0.3–0.4
Minerals (mg)	
calcium	3.4–5
iron	0.6–1.01
phosphorus	11.1–13
potassium	130
sodium	4
Vitamins (mg)	
ascorbic acid	35
thiamine	0.010–0.02
riboflavin	0.026–0.04
niacin	0.02–0.302
vitamin A	105 UI

Recipe and other uses

Bilimbi fruit is too acid to be eaten fresh and commonly is used for pickles, curries, chutney, and preserves. It is also made into a cooling drink similar to lemonade. In the Philippines the fruit is used as the basis of soup stock and in stews. In Hawai'i, chefs use juiced fruit as a substitute for vinegar in salad dressings and soups. It is also dried and reconstituted with other juices and spices for use in sauces.

The sour taste of bilimbi is due to its high oxalic acid content, which ranges from 10.5 to 14.7 mg/g in green fruit and from 8.45 to 10.8 mg/g in ripe fruit. The fruit can be used to remove rust stains and to clean knife blades. There are many uses in traditional medicine. Pastes and poultices of the leaves are used for coughs, itches, skin swellings, and rheumatism, and fruit conserves or syrups are also used for coughs, fevers, and inflammation.

Hot and Sour Soup

Chef Paul Heerlein
Hawai'i Community College, West Hawai'i Culinary Arts

Serving size: 42 portions @ 6 fl oz; yield: 2 gal

12 oz	shiitake mushrooms (stem/whole)-
20 oz	bilimbi juice
4 fl oz	sauce
1 tbsp	sesame oil
1¼ fl oz	chili oil
3 tsp	pepper
2 gal	beef stock
1½ lb	firm tofu in ½-inch cubes (garnish)
12 tbsp	cornstarch
6	eggs well beaten

In a small bowl, stir together the vinegar, soy sauce, sesame oil, chili oil, and ½ tsp pepper. Set aside. In a saucepan over medium heat, bring the stock to a simmer. Add the mushrooms and cool until the stock is aromatic, about 3 minutes. Reduce the heat to medium and add the tofu. Cook until the tofu is heated through, about 2 minutes. Add the reserved vinegar-soy mixture and bring to a simmer. In a small bowl, combine the cornstarch and water and stir until the cornstarch is dissolved. Add to the soup and stir until the soup begins to thicken. Remove from the heat. Add the egg, whisking with a fork until little shreds of cooked egg form. Taste and adjust the seasonings with vinegar, pepper, or soy sauce.

Cost of production

It is essential that growers determine their own cost of production for each crop in each growing location. Including *all* the variables in figuring your cost to produce a specific crop is key to farm sustainability. A few of the operating (or "variable") costs include fertilizer, weed control, pest control, pruning, irrigation, harvesting, marketing, and operations overhead. Ownership (or "fixed") costs also need to be taken into account. For detailed information on the various types of cost, see "The economics of cacao production in Kona" (www.ctahr.hawaii.edu/oc/freepubs/pdf/AB-17.pdf).

The cost-of-production spreadsheet on the following pages can be downloaded as a Microsoft Excel file from www.ctahr.hawaii.edu/oc/freepubs/spreads/6fruits.xls.

Selected references

Coronel, Roberto E. 1983. Promising fruits of the Philippines. University of the Philippines at Los Baños. p. 51–66.

Janick, Jules, and Robert E. Paull. 2008. The encyclopedia of fruits and nuts. CABI Wallingford, Oxon, UK. p. 574–576.

Popenoe, Wilson. 1920. Manual of tropical and subtropical fruits. Hafner Press. p. 431–432.

van Wyk, Ben-Erik. 2005. Food plants of the world. Briza, Pretoria, South Africa. p. 81.

Verheij, E.W.M., and R.E. Coronel. 1992. Plant resources of Southeast Asia, 2: Edible fruits and nuts. PROSEA Foundation, Bogor Indonesia. p. 96–98.

Internet resources

Fruits of warm climates, by Julia F. Morton
www.hort.purdue.edu/newcrop/morton/index.html
Montoso Gardens
www.montosogardens.com
Plant Resources of Southeast Asia
www.prosea.lipi.go.id
International Tropical Fruit Network
www.itfnet.org

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Assumptions: *(Data entries are annual amounts expressed on a per tree basis)*

Fruit tree => BILIMBI

1.	Average number of bearing trees *(counted)*		2	trees
2.	Yield (*expressed in number of fruit [F] or lbs*)	P	100	lbs. / tree
3.	Average wt. (ozs.) / fruit =	1.0	ounces	
4.	Total lbs. harvested/ tree =	100.0	lbs. gross yield	
5.	Marketable yield /tree (%) =	99%	of the gross yield	

To calculate profitability: Enter wage rate & benefits actually paid (or the rates one would to pay if labor were hired.) To calculate cash flow enter nothing.

The cash flow result is (except for depreciation considerations) one's taxable income.

6.	Wage rate ($/hr.) =	$12.00
7.	Benefits (FICA, etc.) (%) =	33.3%

Gross Revenue:	% of total:	$/lb:	Lbs./tree/yr.		$ /tree /yr.:	$ /total crop /yr.	% of gross
1 Wholesale sales	90%	1.00	89.1	marketable lbs.	89.10	178	82%
2 Retail sales	10%	2.00	9.9	marketable lbs.	19.80	40	18%
Total sales =	*Weighted ave. price/lb. = $1.100*		**99.0**	marketable lbs.	108.90	218	100%

Operating Costs: *Enter unit quantities as total per year per tree:*

A. Growing costs:	Units:	$/unit:		¢ /lb. of fruit	$ /tree /yr.:	$ /total crop /yr.	% of gross
1 Fertiliziation			Sub-totals =>	0.04	3.47	6.93	3%
Fertilizer (lbs.)	1.0	$0.80		0.008	0.80	1.60	
Labor (min.)	10	$0.27		0.027	2.67	5.33	
2 Irrigation: *Assuming ag water rate =*	*$2.00*	*/1,000 gals.*	Sub-total=>	0.01	1.34	2.67	1%
Water (gallons)	2	*$0.002*	*/ 1,000 gals.*	0.000	0.00	0.01	
Labor (min.)	5	$0.27		0.013	1.33	2.67	
3 Pest control:			Sub-totals =>	0.00	0.00	0.00	0%
Materials	0.0	$0.00		0.000	0.00	0.00	
Labor (min.)	0	$0.27		0.000	0.00	0.00	
4 Weed control:			Sub-totals =>	0.03	2.67	5.33	2%
Chemicals and/or machinery	0.0	$0.00		0.000	0.00	0.00	
Labor (min.)	10	$0.27		0.027	2.67	5.33	
5 Pruning:			Sub-totals =>	0.03	2.67	5.33	2%
Machinery	0.0	$0.00		0.000	0.00	0.00	
Labor (min.)	10	$0.27		0.027	2.67	5.33	
6 Other:			Sub-totals =>	0.00	0.00	0.00	0%
Materials and/or machinery	0.0	0.00		0.000	0.00	0.00	
Labor (min.)	0	$0.27		0.000	0.00	0.00	
		Total growing costs =		**0.102**	**10.14**	**20.28**	9%

Enter picking costs based on gross yield and packing and delivery costs based on marketable yield .

B. Harvesting costs:	Average cents per pound		¢ /lb. of fruit	$ /tree /yr.:	$ /enterprise /yr.	% of gross
1 Picking	12.0	¢/lb.	12.0	12.00	24.00	11%
2a Packing: for wholesale	-	¢/lb.	0.0	0.00	0.00	0%
2b Packing: for retail sales	69.0	¢/lb.	6.9	6.83	13.66	6%
3 Delivery to market	12.1	¢/lb.	12.1	11.98	23.96	11%
		Total harvesting costs =	**31.0**	**30.81**	**61.62**	28%
		TOTAL Operating Costs =	**31.1**	**40.95**	**81.90**	38%
		Gross Margin =	**78.9**	**67.95**	**135.90**	62.4%

Break-even analysis:

Given the weighted average price of	$1.100	$/lb. fruit, the mkt. yield required to cover operating costs =	**74.5**
Given the marketable yield of	99.0	lbs. fruit/ tree, the ave. price req. to cover operating costs =	**$0.414**

How to calculate your harvesting costs expressed as ¢ / lb:

Picking: *Assume picking labor wage rate =* ***$12.00*** */hour*

1 Weigh *all* of the fruit picked in one harvest year & average it out for one tree. *Ave. gross yield / tree =* 100.0 lbs./year

(Important: The picked fruit yield recorded here is the gross yield and not the marketable yield.)

2 Record how many minutes on average it takes you to pick *all* of the fruit on one tree. **60** minutes

(Note: You will probably havest the tree a number of times during the season. We need the time it takes for the whole crop year.)

3 Divide the ave. gross yield /tree by the ave. time taken to pick. Your average picking rate in pounds per minute = 1.7

4 Divide the hourly wage rate for pickers by 60 minutes.. This will give you the cents per minute wage rate = 20.0

5 Divide this wage rate, in ¢ / min. (result from step 4 above), by the ave. picking rate (in lbs./ min.) (from step 3 above.)

The result is your **cost (in ¢ / lb.) to pick a tree's annual gross yield of fruit =** **12.0 ¢ / lb.**

Example to illustarate the process:

a In one year you picked 1,600 fruit with a total weight of 800 pounds in 1 hour 20 min = 100 minutes. Your average picking rate is: 800 lbs. ÷ 100 minutes = **8 lbs./ min.**

b You would pay pickers $12.00 per hour = 20 ¢ per minute to pick fruit. 12 ÷ 60 = $0.20 or **20¢ per minute**

c Your picking cost / tree is: 20 ¢/min ÷ 8 lbs./ min. = **2.5 ¢/ lb**. per pound of fruit picked

Packing:

1 WHOLESALE: Record the total annual cost for packaging to pack the marketable fruit sold wholesale. **$0.00**

2 Divide this cost by pounds of fruit sold wholesale. (This has been calculated in "Gross Revenue" above) 89.1

Your materials cost in ¢ / lb. = **0.0** ¢ / lb.

3 If more labor (in addition to the picking labor) is required to pack, calculate its cost in ¢ / lb. as above.

Extra labor required (minutes): **0** Packing rate = lbs. / minute Labor cost =

4 Add these 2 costs together to obtain the **total packing cost per pound of fruit marketed wholesale =** **0.0 ¢ / lb.**

5 RETAIL: Follow the same proceedure (steps 1 to 4 above) to calculate the cost to pack fruit sold retail.

Total cost of retail packaging = **$6.83** Retail sales = 9.9 pounds Materials cost = 69.0 ¢ / lb.

Extra labor required (minutes): **0** Packing rate = lbs. / minute Labor cost =

Total packing cost per pound of fruit marketed retail = **69.0 ¢ / lb.**

Example:

a In one year you picked 1,600 pounds of fruit, of which 75% was marketable, that is, 1,200 pounds.

b During the year you used 24 boxes (@ $2 each) to ship 1,200 pounds of fruit to the wholesale market.

c Divide the packaging cost ($48) by the amount of marketable fruit. This will give you the materials cost / lb. of fruit: $48.00 ÷ 1,200 = $0.08 = 4**¢ / lb.**

d During the year 60 minutes of packing labor was required (beyond the picking labor.) Your average packing rate is: 1200 lbs. ÷ 60 min. = **20 lbs. / min**.

e You would pay packers $12.00 per hour (= 20 ¢ per minute) to pack fruit. Your annual packing labor cost /tree is: 20 ¢/min ÷ 20 lbs./ min. = **1.0 ¢/ lb.**

f Add the annual material cost (step c) and labor cost (step e) to obtain your total packing cost / lb. of marketed fruit. 8 ¢/ lb. + 1 ¢ / lb = **9.0 ¢/ lb.** for packing wholesale fruit.

Delivery:

1 Based on your annual records, calucuate your average cost / mile for vehicle & driver to haul boxes: **$1.00**

2 Record the total delivery mileage for one year & estimate a portion to allocate to delivering this crop: **12**

3 Record the total weight of marketable fruit delivered during the year: 99.0

4 Multiply estimated share of mileage times mileage rate & divide by total weight of deliveries: **12.1 ¢ / lb.**

Example:

a You have 10 trees that yield an average of 1,200 lbs of marketable fruit = 12,000 lbs.

b During the year you made 24 deliveries carrying 500 lbs of fruit averaging 20 miles round trip.

c The cost for your vehicle and driver's time averages about $1.00 per mile driven.

Note: Oviously, the average delivery cost / lb. of all fruit marketed, unlike the picking and packing costs per pound of fruit, will vary widely for different growers, depending on their location relative to their markets.

480 miles driven @ $1.00 / mile = **$480** $480.00 transport cost ÷ 12,000 lbs fruit = $0.04 = **4.0 ¢ / lb.** of fruit delivered