

Vegetable Section

COCOYAMS (XANTHOSOMA CARACU, X. ATROVIRENS AND X. NIGRUM), ANCIENT ROOT- AND LEAF- VEGETABLES, GAINING IN ECONOMIC IMPORTANCE

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There are some 38 or 40 species of *Xanthosoma* (family Araceae), all indigenous to the American Tropics (1, 12, 43). Some of them are considered by ethnobotanists and archaeologists to be among the oldest root crops in the world (4, 45) and it is strange that there is little readily available information on the economically important species of this genus. Generally, in literature on root crops, *Xanthosoma* species are discussed jointly with the taro (*Colocasia esculenta* Schott) and this practice tends to obscure the distinction between the two crops. The cocoyams (*Xanthosoma* spp.), though superior comestibly and nutritionally, remain the lesser known. The taro has enjoyed universal publicity through historical and fictional accounts of life on the Pacific Islands and the convenience of its simple, widely familiar, vernacular name has contributed to its general recognition. *Xanthosoma* species, in contrast, are burdened with a multiplicity of highly localized vernacular names: MALANGA and GUAGUI (the latter especially in Matanzas Province) in Cuba; MALANGA or TAYO in Haiti; YAUTIA in the Dominican Republic and the Philippines; YAUTIA or TANIER in Puerto Rico; TANNIA in Trinidad; CHOU CARAIBE in Martinique and Gabon; OCUMO or YACUMO in Venezuela; TAOBA or MANGARETO in Brazil; GUALUZA in Bolivia (14), UNCUCHA in Peru; TAJER in Surinam; OTO in Panama; TIQUISQUE in Costa Rica; QUISCAMOTE in Honduras; COCO, MALANGA or MUNUL in British Honduras; MACAL in Yucatan (11, 47); MACABO in Cameroun; and COCOYAM in Ghana and Nigeria (23, 24, 25). To further complicate matters, *Colocasia esculenta* is known as MALANGA ISLENA in

Cuba (32). Also, the term MALANGA is applied specifically to *Colocasia esculenta* in Puerto Rico and is defined as "taro" in Webster's International Dictionary, with a cross-reference to YAUTIA, which is defined as applicable principally to any species of *Xanthosoma*.

The existing confusion is a serious matter for the agriculturist seeking information, for there are some major differences in the two crops: for example, the *Xanthosoma* species require good drainage while taro can be grown in lowlands too wet for *Xanthosoma* culture. Also, *Colocasia esculenta*, which should be readily recognized by its peltate leaves, is not limited to tropical regions and is grown throughout the coastal plain of our southern States as far north as South Carolina, where it is commonly called ELEPHANT'S EAR (a name popularly given to ornamental forms of *Xanthosoma* and *Alocasia* in South Florida).

In southern Florida, cocoyams have been grown in small patches for many years and on a limited commercial scale since 1963 (7). At the present time, to meet the needs of our Latin American population, *Xanthosoma* and *Colocasia* are being grown together in the same fields as two different types of "MALANGA," the tubers of *Colocasia* being sold in local markets as "YELLOW MALANGA." Because of the increasing commercial interest in *Xanthosoma* as a root crop, not only in Florida but throughout the Tropics, I would like to propose the general adoption of the euphonious and appetizing term, COCOYAM, as a collective trade name for *Xanthosoma* species—a simple name that would come to be recognized throughout the United States and in all countries regardless of regional languages.

It seems timely, too, to suggest abandonment of the designation *Xanthosoma sagittifolium* Schott as a group term. This was the first species to be described and the binomial has been loosely employed by various authors in discussions of the



Fig. 1. Dr. Robert McMillan displays reverse of cocoyam leaf (non-peltate) in contrast with two taro leaves (peltate), reverse and face views, at right.

—Photo by Julia Morton.

Xanthosoma species cultivated for their so-called "roots." Professor Roy W. Woodbury, formerly a member of the Botany faculty of the University of Miami and, for the past several years, working with the University of Puerto Rico in Rio Piedras, declares that he has never seen a specimen of *X. sagittifolium* in Florida. In the opinion of Agronomist Angel Acosta Matienzo, Subestacion de Gurabo, Puerto Rico, most, if not all, of the cocoyams grown for food in Puerto Rico (4), Cuba and now in Florida are of the seldom-mentioned species *X. caracu* Koch & Bouché. Through the generous cooperation of these two valued colleagues, I was able recently to view in farm plots the three species of *Xanthosoma* most grown for food in Puerto Rico, though the University's collection of species and clones has been moved from the Gurabo station to the College of Agriculture, Mayaguez.

The plants and leaves of *X. sagittifolium* Schott (NOT cultivated for its roots in Puerto

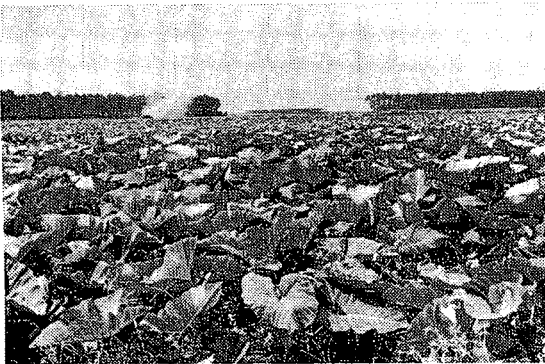


Fig. 2. Cocoyams and taro are cultivated side-by-side in South Dade fields, to meet the local demand.

—Photo by Julia Morton.

Rico nor in Florida) are quite different from those of *X. caracu*. The following brief, non-technical descriptions of these two species and four others of major economic interest are compiled from Acosta and Haudricourt and sundry other sources (3, 8, 9, 12, 18, 30, 39, 58).

X. sagittifolium (or *sagittae-folium*) Schott. Stem of mature plant thick, erect, to 3 or 4 ft. Petioles (to 3 ft. long) and leaves uniformly light-green without powdery bloom. Leaf blade 1-1/3 to 3 ft. long, 16 in. to 2 ft. wide, almost oval, with abrupt point at apex, cordate at the base, usually having 8 primary lateral nerves. Basal lobes subacute, more rounded in the adult plant, especially the inner margin. Basal rib (lowest pair of nerves) not denuded at the sinus; separated from the sinus by leaf tissue nearly to the base. Spathe greenish-white. Cultivated and spontaneous in the Greater Antilles and northern South America. Haudricourt and other writers show it as occurring in Barbados but Gooding et al. have never seen it there and believe that the semi-wild specimens formerly reported as *X. sagittifolium* may be *X. brasiliense* Engl. (27).

X. caracu Koch & Bouché YAUTIA BLANCA; YAUTIA HORQUETA; YAUTIA MANOLA; ROLLIZA; TRINIDAD. Plant is vigorous and reaches 5 to 6 ft.; has no above-ground stem. Petiole is thick, fleshy, flattened above, the wings tinted with violet and the back coated with waxy bloom. Blade is bright bluish-green, glossy above, pale beneath; sagittate, cordate, pointed, 1 to 2 ft. long and larger; up to 15 in. wide, usually with 6 primary lateral nerves. Basal lobes 4 times shorter than the anterior lobe and slightly protruding outward. Basal rib exposed to a distance of 1 1/4 to 2 1/2 cm. (variety ROLLIZA) or as much as 4 cm. (variety BLANCA DEL PAIS). Inflorescence unknown. The tubers are abundant and large, mace-shaped, narrow at the end attached to the stem and broad at the apex. They are uniform and without protruding eyes and roots. The surface is rough, grayish-brown; the apical button ivory. Flesh of ROLLIZA is non-acrid and white. It is of high quality and, after cooking, is still white and firmer than that of *X. nigrum* (q.v.). Occurs in Mexico, Honduras, Colombia, Venezuela, Guyana, Cuba, Dominican Republic and Puerto Rico. Of recent introduction into Cameron (21). This species is widely cultivated in Puerto Rico in fields and home gardens as a food and ornamental plant. Thrives in rich, moist soil (not wet) in part-shade or full sun (58); can tolerate prolonged drought and is as disease-resistant as RASCANA (q.v.). Tubers keep well in dry storage.

Eight clones of this species have been grown at the Gurabo station. One, distinguished as VIEQUERA, is particularly drought-resistant and has especially large and long tubers, almost black externally when wet (4). BLANCA DEL PAIS has a low yield of small, thin tubers lacking uniformity. BISLEY produces few, long, thin tubers of poor appearance and quality. MANOLA tolerates more sun than the others; its leaves are smooth and soft; the tubers rough with many eyes; the flesh yellow or orange.

INGLESA has characteristics which cause Acosta to set it apart from *X. caracu*. The plant is vigorous and reaches 5 to 6 ft. The petiole wings are bordered with purplish-red but the petiole bears longitudinal streaks of dark-green, bright-green and yellow-green which sometimes extend onto the blade. Usually, the blade is all dark-green, with prominent, pale veins. The basal rib is exposed for a distance of 3 cm. in the sinus, at times less on one side of center than on the other. There are numerous medium and small tubers, broader at the attached end than those of YAUTIA BLANCA and VIEQUERA. Some are irregular, rough externally, with markedly protruding eyes. The apical button is yellowish-white, sometimes pink-tipped. Flesh is white and of good quality and the yield is high.

X. atrovirens Koch & Bouché. MARTINIQUE, MARTINICA, YEMA DE HUEVO; AMARILLA DEL PAIS (Puerto Rico); DARK-LEAF MALANGA; INDIAN KALE. Plant has no stem above ground. Attains a height of 5 ft. or more. Petiole is 1 to 2 ft. long, thick, dark-green. The two wings of the petiole are speckled inside and out with ivory, bluish-purple and various shades of rose or maroon; sometimes with streaks of pale-yellow, light-green and dark-green along the lower length of the petiole. The back is covered with waxy bloom. Blade is 28 to 32 in. long and to 2 ft. wide; dark-green above, grayish-green with powdery bloom beneath; the margin green; midrib and veins light-green; anterior



Fig. 3. *Xanthosoma caracu* and *X. nigrum* ('KELLY') in a typical hillside plantation between Gurabo and San Lorenzo, Puerto Rico. Cocoyams grown with good drainage have best keeping quality.

—Photo by Julia Morton.

lobe $2\frac{1}{2}$ times longer than basal lobes. There are 4 to 6 primary lateral nerves. Basal lobes subrhomboid or semi-ovate, obtuse. Basal rib exposed for distance of $2\frac{1}{2}$ cm. or more. Spathe tube green; blade of the spathe dull-green, the apex purplish; veins reddish. Spadix yellow or rose. The underground base of the stem (madre) is yellow-orange inside and is the major edible portion, being tenderer than the tubers. It may reach $2\frac{1}{2}$ kg. in weight and is richer in carotene than other cocoyams. The tubers are few, small, cylindrical, irregular in form, with numerous large roots; brown on the outside, yellow-orange within, acrid when raw, and remain fairly firm after cooking. Around the crown, there occur many small, round, very firm tubers ("eggs") which are usually used only for planting. The apical button may be cream-colored or pale-rose. Cultivated in Puerto Rico, St. Thomas, St. Croix, Cuba and Jamaica. Thrives in rich loam with lime added. For tuber production, requires 40% shade. When grown for its leaves needs full shade and plenty of water. Haudricourt describes 5 botanical varieties, including var. *Moritzi* Engl., the *NUT EDDO* of Trinidad (30).

MARTINICA AMARILLA differs in having pale-yellow-green leaves and petioles and these are covered with a heavy waxy bloom. The wings of the petiole have rose margins and tinges of violet. This form requires more shade than *MARTINICA*. The tubers are fairly firm when cooked.

RASCANA is a well-recognized variety which may belong to this species. It is a vigorous plant, reaching 5 or 6 ft., tolerant of a fairly wide range of soil and climatic con-

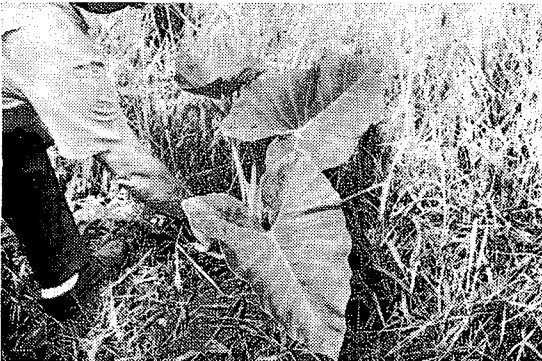


Fig. 4. Agronomist Angel Acosta Matienzo identifying *Xanthosoma caracu* at the Subestacion de Gurabo, Puerto Rico.

—Photo by Julia Morton.

ditions and springing up spontaneously after cultivation. The leaves and petioles are yellowish-green though not as light as those of *MARTINICA AMARILLA*. The leaf surface is smooth, the basal rib is scarcely or not at all exposed in the sinus. There is a slight rosy tone where the petiole meets the leaf blade but no tints on the wings of the petiole. The waxy bloom on the blade and petiole is thin and inconspicuous. The spathe and spadix are greenish-white. The plant produces an abundance of tubers in a compact mass around the base of the stem. They are short, more or less potato-shaped, irregular in form, and thickest at the end attached to the stem; brown and rough on the surface, with ivory or dark-rose apical button. They have many protruding eyes and only a few large roots. Flesh is cream-colored; firm even after cooking. Tubers that are not fully mature are very acrid and the irritant properties are not completely destroyed by cooking. The tubers keep and ship well and are consequently much exported to the United States.

X. nigrum Mansf. (8) (*Arum nigrum* Vell.; *X. violaceum* Schott). *BLACK MALANGA*; *MALANGA NOIR*; *MALANGA MORADA*; *MALANGA COLORADA*; *VINOILA*; *QUESQUE* (El Salvador); *OTO* (Panama); *RASCADERA* (Colombia); *OCUMO MORADO CULIN* or *DANCHI* in Venezuela; *BADU* or *COCO* (Jamaica and Guatemala); *CEBUGABI* (Philippines). Plant is vigorous, attaining 5 to 6 ft.; has no stem above ground. Petiole 1 ft. to 28 in. long, waxy on the back, the wings more or less tinted with rich purple. Leaves ovate or ovate-oblong, sagittate, 8 to 20 in. long, 6 to 16 in. wide. Dark-green on upper surface, pale beneath and often tinged with purple. Ribs and nerves light-green or dark purple; margin usually purple; lateral nerves prominent beneath the blade. Anterior lobe 3 to 4 times longer than the basal lobes and has short, slender point. Basal lobes of blade almost triangular. Sinus acute, open. Basal rib exposed for 2 cm. Young leaves have conspicuous, bluish-powdery bloom at first; later become green. Tube of spathe violet or pale-green outside, creamy within. Blade of spathe yellowish-white or yellowish-green with longitudinal purple veins. There is a large underground rhizomatous stem (usually referred to as the rhizome) and numerous lateral tubers, larger and more symmetrical than those of other species. The stem-end of the tubers is thicker than in *X. caracu*. There are only a few protruding eyes and roots. The exterior is smooth and purplish-gray. The eyes and the apical button are dark purplish-red. Flesh varies in color from violet or wine-red with dark veins to pink, light-yellow or white, sometimes streaked with purple. Cooking changes the colored types to gray. The rhizome, as well as the tubers, is used for food; also the young leaves and petioles. This species is much cultivated for food in Puerto Rico (thriving on the red clay of the mountainsides), in Haiti, the Dominican Republic (34), Cuba (32), in Panama (50) and British Honduras (61), at Alta Verapaz and Izabal in Guatemala (52), in Venezuela (46) and many other areas in tropical America, and in Cameroun (31), Java (8) and the Philippines (13).

KELLY is a less vigorous variety of this species. The petiole is darker in hue, the wings being brownish-purple. The leaf blade is lighter green and the veins are less prominent. Sometimes the midrib is light-maroon on the underside. The basal rib is exposed for a distance of only 1 cm. in the sinus. The tubers differ from the foregoing in having yellow apical button tipped with red, and yellow flesh. They lose their acidity and become soft with cooking and are well recognized in the market as distinct from the yellow tubers of *X. atrovirens* (4). Unfortunately, they tend to rot if left in the ground too long and they are not suitable for shipping.

DOMINICANA, or *GUAYAMERA*, may be a variety of *X. nigrum*. The plant is vigorous and erect, to 5 or 6 ft. in fertile soil. It has conspicuous black-purple petioles and midribs, coated with bluish, waxy bloom (4). The leaf blade is green with purplish tints and attached obliquely or at a right-angle to the petiole. The basal rib is scarcely or not at all exposed in the sinus. The tubers are of medium or small size, round or irregular without protruding eyes or roots; rough and grayish-brown on the surface, with light-yellow apical button tipped with pink. The flesh is cream-colored and firm even after cooking (4). The plant yields poorly and is seldom planted.

X. jacquinii Schott (*X. sagittifolium* Lieb.). *YAUTIA PALMA*; *YAUTIA HUECA*; *YAUTIA SILVESTRE*; *MALANGA COCHON*; *GIANT TANIER*. Plant has acrid, milky sap and a foetid odor. Stem of mature plant erect or

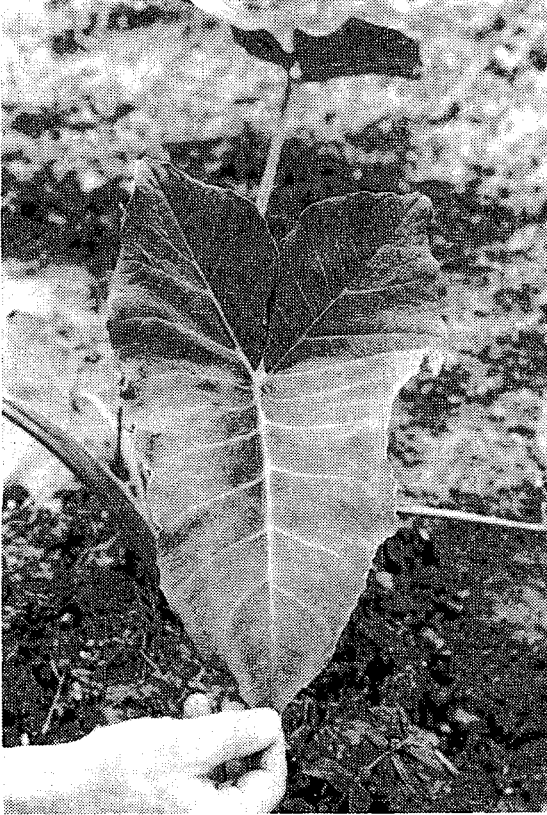


Fig. 5. *Xanthosoma atrovirens* 'MARTINICA AMARILLA,' at the Fairchild Tropical Garden Research Center. —Photo by Julia Morton.



Fig. 6. *Xanthosoma nigrum*, 'KELLY,' posed by Agronomist Angel Acosta Matienzo and Professor Roy Woodbury at the Subestacion de Gurabo, Puerto Rico. —Photo by Julia Morton.

reclining, 3 to 8 ft. long and to 6 in. thick. Petiole to 6 ft. long and 3 in. wide at base. Leaf blade dark-green above, pale below; with prominent midrib and veins; to 30 in. wide and 40 in. long; apex rounded with abrupt, short point; usually 6 to 8 primary lateral nerves. Basal lobes obtuse, 6 to 20 in. long. Sinus broad and open. Basal rib exposed near the base and along the edge next to the sinus for a distance of 1 to 1½ cm. Flowering occurs frequently. Spathe tube green or yellow-green outside, purplish inside; spathe blade green outside, whitish inside. The mature inflorescence is unpleasantly odoriferous. Cultivated and naturalized in Florida, Puerto Rico, the Dominican Republic, Lesser Antilles, Mexico and in Venezuela, Ecuador and other areas of South America from sea level to 3,000 ft. Needs dense or partial shade. Grown as an ornamental as well as for pig feed in Puerto Rico. The stem base, casually referred to as the rhizome, may reach a diameter of 6 in. in one year and a weight of 10 lbs. It is yellow-orange inside and is acrid, but if sliced, sun-dried and cooked can be utilized for human food. The small lateral tubers are rarely formed. In Surinam they and the leaves are cooked and eaten. In the Andes of southern Colombia, the tubers are ground, boiled and fermented to make *chicha*, an intoxicating drink.

X. brasiliense Engl. (*X. hastifolium* Koch). BELEMBE; QUELEMBE; CALALOU; TAHITIAN SPINACH. This plant need not be described in detail here. It is valued for its nutritious leaves which are commonly cooked like spinach in Puerto Rico, Haiti, the Lesser Antilles, southern Brazil and Hawaii. It has tubers which are non-acrid and edible but tiny—¼ to 1 in. wide. Propagated by offshoots and grown the year around in home gardens (33).

X. belophyllum Kunth. TURIARA. Leaves of this species are sold in Caracas markets for use in salads (43) after cooking in salted water (10).

Variety Preference. In Puerto Rico, the most valued cocoyams are the MARTINICA and MARTINICA AMARILLA and the supply is never sufficient to meet the demand. The other commercially prominent varieties are VINOLA, KELLY, RASCANA and BLANCA (4). In Ghana and Gabon, the pink-, red-, or purple-fleshed tubers are most popular (31, 54).

Economic Status

Over the past 40 years, there has been a steady trend in tropical agriculture away from the taro (including the dasheens), *Colocasia esculenta*, and toward increased planting of cocoyams (*Xanthosoma* spp.). Compared with other starchy food crops, cocoyams bring a high yield with a minimum of labor (4). In 1949, Williams wrote that cocoyams brought double the price of cassava (*Manihot esculenta* Crantz) (55). In 1951, cocoyams were said to be largely replacing taro in the

Philippines because the tubers were larger, more mealy and mucilaginous and the people preferred the taste (13). In Venezuela, cocoyam production in 1960 was double that of 1937 and totaled 70,000 metric tons. Half the crop was produced in the State of Sucre (1). Coursey writes that the current rapid shift from taro to cocoyams in Africa (14) is apparently because the cocoyam is more suitable for manufacturing the popular food product, *fufu*, a paste formerly made of yams (*Dioscorea* spp.) (19). The tubers and leaves form a major part of the diet of the people of Gabon (5). Speaking of Ghana, Karikari says: "Generally, cocoyams are not grown on a large scale. However, they are of immense importance and in every farm, garden or smallholding this crop is grown. The total acreage and annual production are therefore considerable . . . Because of its excellent storage quality, it is the one most often used as a travelling food by local people. When famine threatens, as it often does, cocoyam is the crop which is most frequently sought for to alleviate the situation. In fact, when people talk of famine in this country they refer primarily to a shortage of cocoyams." (31).

In a consumer survey in Puerto Rico (1949-50), the majority of families preferred cocoyams over yams, sweet potatoes, plantains and green bananas (28). There is presently a shortage of cocoyams in Puerto Rico where the price has risen from 5¢ per lb. in 1931 to 25¢ in 1972. In the 1964-5 season, the Puerto Rican crop amounted to 17,700 tons valued at \$2,620,000, mostly for domestic consumption with a small export to the United States (4).

Propagation

The plant top ("head" or *maman*) (56) may be used as planting material, or the underground stem (primary corm), whole (25) or cut into pieces, each piece with about 4 eyes (29). The primary corm has been found to give better, quicker growth and higher yields than the secondary corms, or tubers, which are sometimes employed (2, 23). The top should be set lower in the ground than it was originally—about 32 to 40 in. deep—and its leaves are trimmed (53). Corms or pieces should be set 3 to 5 in. below the surface. *A. atrovirens* may be propagated from offshoots or by rootstock division (29). *A. jacquinii* is grown from suckers (58). Requirement of tops per hectare may be 8,000 to 10,000 (17) or 10,000 to 15,000 (53) depending on spacing.

Culture

Cocoyams thrive up to an altitude of 5,000 ft. in tropical and near-tropical zones (29). For best growth, the soil should be porous, rich in humus. In Florida, plantings have been successful on low-lying marl but good crops have also been obtained on scarified oölitic limestone (7). The plant has a high moisture requirement but needs less water than taro and better drainage.

Spacing of 4 x 4 ft. has been recommended in good soil; 3 ft. x 3 ft. in poor soil. In Puerto Rican tests, a population of 7,260 plants per acre produced 75% more than 4,840 per acre and the yield increased with density up to 14,520 plants per acre (2). However, in Nigeria, Enyi reports that increasing spacing to 5 ft. x 5 ft. stepped up the yield, particularly when secondary corms were used as setts (23).

Ideal planting time is said to be generally in



Fig. 7. *Xanthosoma jacquinii* at the Fairchild Tropical Garden, Miami, Fla. This stout-stemmed species is favored as an ornamental and is important for pig feed in Puerto Rico.

—Photo by Julia Morton.



Fig. 8. BELEMBE (*Xanthosoma brasiliense*) is cultivated for its nutritious leaves in the West Indies, Brazil and Hawaii. This specimen is at the Fairchild Tropical Garden Research Center.

—Photo by Julia Morton.

the spring before the onset of rains. In Jamaica, planting is usually done from January to April or June to August (29). In Puerto Rico, December to April is considered best. The crop needs 1,000 mm. of rain in its early stages. The field is prepared during the dry season; cleared and thoroughly cross-disked to a depth of 10 or 12 in. (6) except on steep slopes where tilling is omitted to avoid erosion (2). Working-in of sugarcane waste is strongly recommended—25 tons per hectare if the soil is red clay or dark sandy clay; 50 tons per hectare if the soil is light and sandy. Fertilizer should be applied twice at the rate of 650 kg. per hectare, the first application in the bottom of the furrows or distributed between the plants immediately after planting. The field should be watered the day before planting. Amargos recommends the following mixture for 1,000 kg. fertilizer: 120 kg. 46% urea; 230 kg. tankage; 210 kg. bonemeal; 110 kg. 20% superphosphate, 140 kg. potassium chloride; 100 kg. potassium sulphate; 65 kg. magnesium sulphate; 10 kg. manganese sulphate; 10 kg. copper sulphate; 3 kg. boric acid; 2 kg. zinc sulphate. This is equivalent

to a 7-4-13 formula (6). Childers *et al.* recommend per hectare: 112 kg. nitrogen; 40 kg. phosphoric acid (P_2O_5); 112 kg. potassium (K_2O) (16). In field studies at Gurabo, Puerto Rico, a 12-6-16 formula was applied twice, 2 oz. in each hole at planting time and 2 oz. per plant after 60 days, and the yield was only moderate (4). Abruña-Rodríguez *et al.* favor 100 lbs. nitrogen per acre; 40 lbs. phosphorus (or 92 lbs. P_2O_5); and 100 lbs. potassium. They found that sodium nitrate seriously reduces yields (2). In Florida, the plants often exhibit interveinal chlorosis which is remedied by chelated iron (Sequestrene 330 and 138)—40 lbs. in 3,000 gals. water per acre (7). Detailed studies of minor element deficiencies have been reported from Trinidad (48).

Weeding, by cultivation or otherwise, should take place 20 or 30 days after planting and again in 30 to 35 days (6). In chemical weed control experiments, Prometryne gave excellent results, Amiben performed satisfactorily, but Simazine proved toxic to the crop (2). After 35 days, growth of the crop should be so rapid as to shade out weeds and make further weeding unnecessary (6).

Mulching hastens sprouting and enhances yield (23). Inflorescences, which must be cut out, appear in 5-6 months, or 7-8 months, depending on the fertility of the soil (6). 50% shading by trees or by interplanted bananas or plantains has been shown to reduce yield by 66-2/3% (2).

Florida cocoyam culture has suffered periodic reverses due to unfavorable weather conditions. Overhead sprinkler irrigation has been found to afford protection from light frosts (7).

Pests and Diseases

Nematodes will inhibit cocoyam growth and for this reason the crop is often planted on virgin soil. The principal insects reported as damaging the plant are: a hairy caterpillar, mealybug, and cotton lacebug (16); woolly aphids, scale insects and red spiders (in very dry seasons) (6). These pests may be controlled by spraying with malathion or trithion. The fungi, *Cladosporium colocasiae* and *Phyllostica colocasiae*, have caused leaf-spotting in Ghana (22, 31). Wireworms, white grubs and a smooth, black or dark-brown boring caterpillar may occasionally attack the corms (16), as will a Dynastid beetle (*Ligyryus ebenus*) (19).

Currutaca, a soft rot of the rhizomes and tubers is caused by the fungus *Pythium ultimum* Trow. It is believed to be induced by excessive soil moisture, high acidity, potash deficiency and lack of crop rotation (5). *X. jacquini* is highly resis-

tant to this disease (22). *X. atrovirens* is less disease-resistant than other species (1, 3). Stored tubers are subject to attack by an Anthribid beetle (*Araecerus fasciculatus*) (26).

Harvesting

The crop matures in 9 or 10 months, but partial harvesting can begin ordinarily in 6 months, removing only the tubers that show white at the tips. This practice actually increases the yield because removal of the larger tubers hastens the development of the rest. If the plants are left in the ground, harvesting may be repeated every 3 months for total periods of up to 18 months, the continuous harvesting discouraging foliage production and encouraging tuber formation (56). In Cameroun, the first harvest is taken in 3 months and 3 or 4 collections follow at intervals of 2 or 3 weeks (16). When the growing period is terminating, the leaves start yellowing around the edges.

Manual harvesting may be accomplished efficiently by 3 men, 2 wielding shovels to loosen the soil and the third bending the plant over to expose the corms (16). In large fields, the potato plow may be used as a mechanical aid to harvesting, as it loosens the soil around and beneath the plants and facilitates pulling them up and detaching the rhizomes and tubers (6). A mechanical yam harvester has been tried in Trinidad. It required the preliminary hand cutting of the plants close to the ground. Though it harvested nearly 12 times faster than hand labor, the damage to tubers (6.8%) was excessive (25).

In Bolivia, the rhizomes and tubers are left in heaps in the open air to mellow (lose their acidity) (1). Generally, they are piled and covered with the leaves of the plants or with some other material such as palm fronds until they can be conveyed to a shaded area where they are spread out in a single layer, the tubers and rhizomes separated and the soil removed. Prior to marketing, they are washed (6).

Harvesting of leaves. When *X. atrovirens* is grown for its leaves, cutting can begin in 6 weeks and can take place twice a week (29). In regard to *X. brasiliense*, Lind *et al.* say that the dark-green outside leaves showing no yellowing at the edges may be cut whenever needed (33).

Yield of Cocoyams

Yield reports vary greatly and are heavily influenced by the cultivar, the soil, weather, spacing,

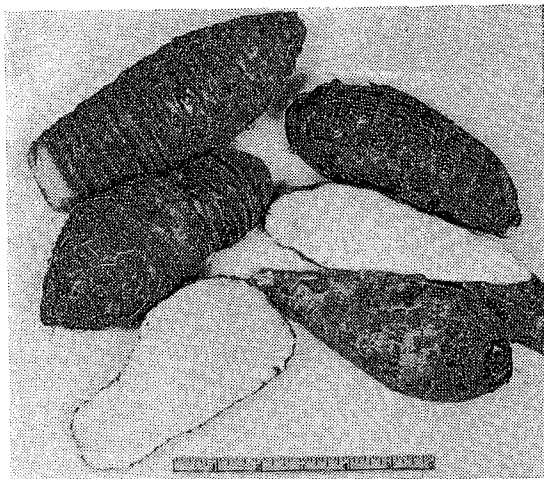


Fig. 9. Left: taro (yellow-fleshed) from the Dominican Republic. Right: cocoyams (white-fleshed) grown in South Florida.

—Photo by Julia Morton.

fertilization and methods of harvesting. The two R. O. Williams' wrote in 1951: "The late Mr. J. R. Bovell, of Barbados, conducted experiments with many varieties of tannias for a number of years and he showed that an average yield of from 3,000 to 5,000 lbs. of tubers and 1,000 to 3,500 lbs. of rhizomes may be expected, according to variety" (56). The Kizibani Experimental Station reports 6,000 lbs. per acre in Zanzibar (55). In Puerto Rico, any amount from 7 to 15 tons per acre may be realized (2). Gooding reports that the variety Barbados has given 13.8 tons per acre in Trinidad (26).

Storage

Experiments in Trinidad have shown that certain cocoyams of good keeping qualities can be kept on wire racks in dry, well ventilated storage at an average temperature of 79° F. and humidity of 76% for 9 weeks. In refrigerated storage, at 45° F. with 80% relative humidity, they will remain in good condition for 18 weeks or more (26). Barrett wrote that tubers of ROLLIZA, after remaining 7 months in his office, were planted and produced strong, healthy plants (1). There may be 7 to 11% loss of weight through moisture evaporation in storage (26). In Ghana, farmers bury the tubers in the ground, watering them occasionally, and thus keep them for several months without dehydration (30). In northern Ghana, the tubers are sliced and sun-dried before storage

in order to have them available all year as a source of flour (30).

Properties and Food Value

The plants, rhizomes and tubers contain, to a varying degree, barbed and grooved raphides (crystals of calcium oxalate) which cause oral and intestinal irritation but which are wholly or largely dispelled by cooking (20, 52, 55). In addition, there are present, particularly in the highly colored varieties, water-soluble saponins, or glucosaponins (16), which are not destroyed by heat but released into the cooking water. The latter has proved as toxic to rats as the raw tubers.² The forms commonly grown as ornamental plants in South Florida are frequent causes of oral irritation in children who bite or chew the raw petiole or leaf blade. In Surinam, people hold the superstitious belief that if one breaks a leaf of even the relatively non-irritating types while the plant is growing, the tubers will be acrid. If they find, when peeling tubers, that one in the batch irritates the hands, they put rum, whiskey or brandy or even a rusty nail in the pot to remove the irritant. If all of the tubers irritate the hands, they are not used for food (21).

Cocoyams (especially the yellow types) are more nutritious than taros and Irish potatoes; less nutritious than sweetpotatoes, plantains and pumpkins (28).

The following low and high values for cocoyam constituents are amalgamated from the analyses of "*X. violaceum*" by Munsell *et al.* in Central America:

Moisture, 58.3-67.5 gm.; ether ext., 0.16-0.41 gm.; crude fiber, 0.5-1.7 gm.; nitrogen, .193-.392 gm.; ash, .87-1.24 gm.; calcium, 6.7-18.5 mg.; phosphorus, 48.3-83.2 mg.; iron, 0.34-4.49 mg.; carotene, .002-.012 mg.; thiamine, .112-.150 mg.; riboflavin, .017-0.45 mg.; niacin, .585-.810 mg.; ascorbic acid, 7.0-14.1 mg.—per 100 gm. (35, 36, 37, 38).

Busson, in West Africa, gives amino acid content of "*X. violaceum*" as follows: (N = 16 p. 100) — arginine, 5.6; cystine, 0; histidine, 1.2; isoleucine, 2.1; leucine, 4.5; lysine, 2.6; methionine, 0.4; phenylalanine, 3.6; threonine, 2.3; tryptophane, 0; tyrosine, 2.6; valine, 3.6; aspartic

acid, 9.4; glutamic acid, 8.1; alanine, 3.4; proline, 2.7; serine, 3.9 (14).

The leaves of *X. brasiliense* are reported in Hawaii to be an excellent source of carotene, a good source of ascorbic acid and a fair source of thiamine (33). The protein content of young leaves varies from 2.2 to 4.1% as compared with that of tubers—1.1 to 1.7%—according to Terra (53).

Preparation and Culinary Uses

Tender cocoyams are washed and peeled before cooking. Some (especially highly colored types in Cameroun) are so hard that they require cooking before peeling (16).

Cocoyams may be boiled, baked, steamed, creamed, mashed, fried; used in soups, chowders, stews, salads, or made into flour or meal for pastry which is stuffed with meat or other fillings. In Surinam, the pastry stuffed with chicken or fish constitutes the national dish called *pom* (21, 42, 49).

Willsey and Vilá, in Pub. No. 1 of the Department of Home Economics, University of Puerto Rico, presented 30 recipes for cooking cocoyams, plus directions for preparing sauces to accompany several of the dishes (57).

Cuban people are partial to cocoyam fritters (*frituras de malanga*) and the ingredients may vary according to taste. The following method is simple and the product so delicious that if it were more widely known I am sure a nationwide demand for cocoyams would be generated. Cocoyams (1 lb.) are peeled (not far in advance else they will darken), cut into small pieces, and placed in a blender until the jar is $\frac{3}{4}$ full. One raw egg is added, plus a tablespoon of freshly and finely chopped parsley, 2 tablespoons of evaporated milk; 1 clove of garlic, minced; 1 teaspoon of salt, 1 teaspoon of vinegar. When thoroughly blended, the batter is dropped by the tablespoonful into hot cooking oil and turned once or twice to form uniformly crisp, golden-brown balls, irresistible as cocktail snacks or as a starchy mealtime vegetable. Mayas in Yucatan peel, cook, mash and mix cocoyams with honey. When food is scarce, they blend uncooked cocoyams with maize to make *masa* for tortillas (12). In Ghana, besides the pasty *fufu* eaten with soup, boiled or roasted cocoyams may be mashed, red palm oil added, and the product eaten with fish or peanuts (31).

In the Dominican Republic, cocoyam pudding is popular. It requires 3 lbs. cocoyams; 1 coconut; $\frac{3}{4}$ lb. sugar; 2 eggs; 2 tablespoons of butter; 2 tablespoons of cooking oil; 1 teaspoon salt; 1 tea-

¹Sakai, W. S., M. Hanson and R. C. Jones. Raphides with Barbs and Grooves in *Xanthosoma sagittifolium* (Araceae). Science 178 (4058): 314-315. Oct. 20, 1972.

²Clark, A. Examination of the Effects of Feeding Rats Upon Tannia, a Member of the Family Araceae. Trans. Royal Soc. Trop. Medic. and Hyg. 23(2):167-172. Aug. 1929.

spoon nutmeg; ½ teaspoon cinnamon; 1 teaspoon gelatin. Peel, boil and mash cocoyams; add coconut water, sugar, butter, oil, seasoning and gelatin; pour into greased mold; put butter on top and bake at 350° F. (41). In the Philippines, cocoyams are often peeled, cooked, dried, ground into flour, mixed with grated coconuts and made into pastries (13).

Leaves: Cocoyam leaves are prized as human food in many regions, but not in Colombia (44). They serve as the main or only cooked greens for most of the population of Ghana (31). In Jamaica, the young leaves are usually boiled, chopped fine, served with butter, pepper and salt, sometimes topped with poached eggs (29).

In Surinam, where the leaves are the leading green vegetable, they are first cooked in lightly salted water, drained, beaten to a paste or puree, and cooked again with a little milk, butter and black pepper (21). In Hawaii, the leaves are boiled or steamed, with salt and butter or evaporated milk or prepared coconut milk, or are stuffed with fish, bacon, lemon and onion slices, seasoned, tied, and then steamed or baked (33).

Other Uses

Surplus cocoyams are fed to poultry as well as to pigs (1). The leaves provide fodder for cattle and the tuber peelings (fresh or dried) are fed to cattle, pigs, sheep and goats in Ghana (31).

References

1. Anonymous. Venezuela y Sus Recursos. Cultural Venezolana, Caracas. 1964. p. 344.
2. Abruña-Rodríguez, F., E. G. Boneta García, J. Vicente-Chandler and S. Silva. Experiments on Tanier Production with Conservation in Puerto Rico's Mountain Regions. *J. Agr. Univ. of Puerto Rico* 51(2): 167-175. Apr. 1967.
3. Acosta Matienzo, A. Identificación y Descripción de las Variedades de Yautía (*Xanthosoma*) en la colección de la Subestación en Gurabo, 1965. Misc. Pub. 67. Univ. de Puerto Rico. Est. Exp. Agr., Río Piedras. July, 1969.
4. _____, and J. Velez Santiago. Yield Trials with *Xanthosoma* Varieties. *J. Agr. Univ. of Puerto Rico* 54 (3): 562-569. July, 1970.
5. Alvarez-García, L. A., and A. Cortés-Monllor. Currutaca: A Pythium Soft Rot of *Xanthosoma* and *Colocasia* spp. in Puerto Rico. *J. Agr. Univ. of Puerto Rico* 55 (1): 78-84. Jan., 1971.
6. Amargós, J. L. Siembra, Cultivo y Cosecha de la Malanga. *Esso Agrícola* 19 (1): 4-9. 1963 (reprinted from La Hacienda).
7. Averre, C. W., III. Malanga Culture in Dade County—Problems and Progress. Mimeo. Report SUB67-3. Univ. of Fla. Inst. Food & Agr. Sci. Subtrop. Exp. Sta. Mar., 1967.
8. Backer, C. A. and R. C. Bakhuizen van den Brink, Jr. Flora of Java. Vol. III. Wolters-Noordhoff N.V., Groningen, Neth. 1968.
9. Bailey, L. H. Manual of Cultivated Plants. Rev'd ed. The Macmillan Co., New York, 1949.
10. Barrett, O. W. Las Yautias de Puerto Rico. *Bol. 6. Estación de Experimentos Agrícolas de Puerto Rico, Mayaguez*. 1905.
11. Benedict, F. G. and M. Steggerda. The Food of the Present-Day Indians of Yucatan. Contrib. to Amer. Archaeology No. 18. Reprinted from Pub. 456 of Carnegie Inst. of Wash. pp. 155-188. June, 1936.
12. Britton N. L. and P. Wilson. Botany of Porto Rico and the Virgin Islands. (Sci. Surv. P.R. and V.I. Vol. 5, Pts. 1-4) New York Acad. Sci. 1923-4.
13. Brown, W. H. Useful Plants of the Philippines, Vol. 1 (Tech. Bul. 10). Phil. Dept. Agr. & Nat. Res., Manila. 1951.
14. Busson, F. Plantes Alimentaires de l'Ouest Africain. Leconte, Marseille, France. 1965.
15. Cardenas, M. Manual de Plantas Economicas de Bolivia. Imprenta Icthus, Cochabamba, Bolivia. 1969.
16. Catherinet, M. Note Sur la Culture du Macabo et du Taro au Cameroun. *Agr. Trop.* 20(8): 717-723.
17. Childers, N. F., H. F. Winters, P. Robles and H. F. Plank. Vegetable Gardening in the Tropics. Cir. 32. Fed. Exp. Sta. in P.R. (of the U.S.D.A.), Mayaguez 1950.
18. Chittenden, F. J. The Royal Horticultural Society Dictionary of Gardening. Vol. IV. Oxford at the Clarendon Press, 1951.
19. Coursey, D. G. The Edible Aroids. *World Crops* 20 (4): 25-30. 1968.
20. Dahlgren, B. C. and P. C. Standley. Edible and Poisonous Plants of the Caribbean Region. NAVMED 127. U. S. Navy Dept., Bur. Med. & Surg., Wash. 1944.
21. deGraaf, Sr. Huize Helena, Willemstad, Curacao. Personal communication. Aug. 19, 1966.
22. Doku, E. V. Root Crops in Ghana. *Proc. Int'l Symp. on Trop. Root Crops*. Vol. 1, pp. III, 39-68. 1967.
23. Envi, B. A. C. Effects of Age on Establishment and Yield of Cocoyam Setts (*Xanthosoma sagittifolium* Schott.). *Expl. Agr.* 3: 121-127. 1967.
24. _____. Effect of Spacing, Sett Size, Ridging and Mulching on the Development and Yield of Cocoyam (*Xanthosoma sagittifolium* Schott.).
25. _____. Growth of Cocoyam (*Xanthosoma sagittifolium* Schott.). *Indian J. Agr. Sci.* 38 (4): 627-633. 1968.
26. Gooding, H. J. and J. S. Campbell. Preliminary Trials of West Indian *Xanthosoma* Cultivars. *Trop. Agr., Trin.* 38(2): 145-152. Apr., 1961.
27. A. R. Loveless, and G. R. Proctor. Flora of Barbados. Overseas Res. Pub. No. 7. Min. of Overseas Development, London. 1965.
28. Haddock, D. and L. Hernandez. Consumer Preferences for Taniers (*Xanthosoma* spp.) in Puerto Rico, 1949-50. *Bull. 103. Univ. of Puerto Rico, Agr. Exp. Sta., Río Piedras*. Apr., 1952.
29. Harris, W. Notes on Fruits and Vegetables in Jamaica. Gov't Ptg. Office, Kingston. 1913.
30. Haudricourt, A. Los Colocasees Alimentaires (Taros et Yautias). *Rev. Internat. de Bot. Appliquee et d' Agric. Trop.* Vol. 21: 233-234. 1941.
31. Karikari, S. K. Cocoyam Cultivation in Ghana. *World Crops* 23 (3): 118-122. May/June, 1971.
32. Leon, Hno. Flora de Cuba. Vol. I. *Contrib. Ocas. 8. Museo de Historia Natural del Colegio de la Salle. Cultural, S.A., Havana*. 1946.
33. Lind, H. Y., M. L. Bartow, and C. D. Miller. Ways to Use Vegetables in Hawaii. *Bul. 97. Univ. of Hawaii, Agr. Exp. Sta., Honolulu*. 1946.
34. Moscoso, R. M. *Catalogus Florae Domingensis, Pt. 1. Univ. de Santo Domingo*. 1943.
35. Munsell, H. E., L. O. Williams, L. P. Guild and R. S. Harris. Composition of Food Plants of Central America. V: Nicaragua. *Food Res.* 15 (5): 355-365. 1950.
36. _____, L. T. Kelley, A. M. McNally, and R. S. Harris. Composition of Food Plants of Central America. VI: Costa Rica. *Food Res.* 15 (5): 379-404. 1950.
37. _____, C. B. Troesch, G. Nightingale and R. S. Harris. Composition of Food Plants of Central America. I: Honduras. *Food Res.* 14 (2): 144-164. 1949.
38. _____, L. T. Kelley and R. S. Harris. Composition of Food Plants of Central America. VII: Honduras. *Food Res.* 15 (6): 421-438. 1950.
39. Neal, M. In Gardens of Hawaii. Rev'd ed. Spec. Pub. 50. Bernice P. Bishop Museum, Honolulu. 1965.
40. Ochse, J. J. and R. C. Bakhuizen van den Brink. Vegetables of the Dutch East Indies. *Dept. of Agr., Indus. & Comm. of the Neth. E. Indies, Buitenzorg, Java*. 1931.
41. Ornes de Perello, A. *Cocina Criolla*. Editora del Caribe. C. por A., Ciudad Trujillo. 1955.
42. Ostendorf, F. W. Nuttige Planten en Sierplanten in Suriname. *Bul. 79. Landbouwproffstation in Suriname, Paramaribo*. 1962.
43. Patiño, V. M. Plantas Cultivadas y Animales Domesticos en America Equinoccial. Vol. II: Plantas Alimenticias. *Imprenta Departamental, Cali*. 1964.
44. Perez-Arbelaez, E. Plantas Utiles de Colombia. 3rd

- ed. Libreria Colombiana—Camacho Roldan (Cia. Ltda.), Bogotá, 1956.
45. Plowman, T. Folk Uses of New World Aroids. *Econ. Bot.* 23 (2): 97-122. 1969.
46. Schnee, L. Plantas Comunes de Venezuela. *Alcance No. 3, Revista de la Fac. de Agronomía de la Univ. Central de Venez.* pp. 444-445. Oct. 1960.
47. Souza-Novelo, N. Plantas Alimenticias y Plantas de Condimento que Viven en Yucatan. *Inst. Tec. Agr. Henequenero, Merida.* 1950.
48. Spence, J. A. and N. Ahmad. Plant Nutrient Deficiencies and Related Tissue Composition of Tannia (*Xanthosoma sagittifolium*). *Proc. Int'l Symp. on Trop. Root Crops.* Vol. I. 1967.
49. Stahel, G. De Nuttige Planten van Surinam. *Bul. 57. Dept. Landbouwpref-station in Suriname. Paramaribo.* 1942.
50. Standley, P. C. Flora of the Panama Canal Zone. *Contrib. U. S. Nat. Herb. Vol. 27. Smithsonian Inst., Wash.* 1928.
51. _____, and S. J. Record. The Forests and Flora of British Honduras. *Pub. 350. Bot. Ser. Vol. XII. Field Mus. Nat. Hist., Chicago.* 1936.
52. _____, and J. A. Steyermark. Flora of Guatemala. Vol. 24, Pt. 1. *Chic. Nat. Hist. Mus., 1958.*
53. Terra, G. J. A. Tropical Vegetables. *Roy. Trop. Inst. & Neth. Org. for Int'l Assist., Amsterdam.* 1966.
54. Walker, A. R. and R. Sillans. Plantas Útiles du Gabon (*Encyc. Biol. LVI*) Editions Paul Le Chevalier, Paris. 1961.
55. Williams, R. O. Useful and Ornamental Plants in Zanzibar and Pemba. Gov't Printer, Zanzibar Protectorate. 1949.
56. _____, and R. O. Williams, Jr. Useful and Ornamental Plants of Trinidad and Tobago. 4th ed. Guardian Com'l Pty., Port-of-Spain, Trinidad. 1951.
57. Willsey, E. M. and C. J. Vilá. Vegetales Tropicales: Yautía. *Pub. No. 11. (Bul. No. 3, Whole No. 8) Dept. of Home Economics, Univ. of Puerto Rico, Coll. of Educ., Rio Piedras.* 1931.
58. Winters, H. F. Some Large-leaved Ornamental Plants for the Tropics. *Cir. 35. U.S. Dept. Agr., Fed. Exp. Sta. in Puerto Rico, Mayaguez.* 1952.
59. _____, and G. W. Miskimen. Vegetable Gardening in the Caribbean Area. *Agr. Handbook 323. U.S. Dept. Agr.: Agr. Res. Serv., Wash.* 1967.

COMPETITION AT WHAT PRICE? AN OLD QUESTION IN A NEW ERA FOR FLORIDA VEGETABLE CROPS

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Abstract. The competitive position (market share) of Florida's vegetable crop subsector is threatened by an intensified cost and price squeeze. While the state's share of the overall U.S. output of most vegetable products has not deteriorated over the past 15 years, that of some important truck crops (tomatoes, cucumbers, peppers, eggplant, and strawberries) for winter markets has failed to keep pace with consumer demand increases. Imports have risen sharply to absorb consumption increases. In the process, Florida's share of the U. S. market has diminished.

Added to the downward pressure on prices by imports is the upward pressure on costs occasioned by policies to control pesticide use and to raise wages for farm workers. Further import restrictions provide a potential stopgap solution to protecting Florida's market share from both of these pressures by shifting part of the adjustment responsibility to consumers in the form of higher prices. The ability to make this shift, however, is becoming more difficult due to mounting governmental attempts to suppress inflation and reduce barriers to international trade. The dilemma of "competition at what price?" is one of concern

and conflicting interests among Florida producers, Florida agricultural workers, U. S. consumers and international trade policy makers. Numerous questions are raised in this paper for which adequate answers must be sought in the near future.

Introduction: Old Questions

With the concern by vegetable growers and producers about unionized farm labor and Mexican imports some ask—*Are vegetable crops important to Florida's economy?* Floridians reply strongly to the affirmative: but how important is the vegetable subsector to the state's economy? Common responses are that 1) vegetables, melons, potatoes and strawberries grown in Florida were valued at \$280.9 million for the 1970-71 crop year (3), 2) for calendar year 1971 these crops accounted for more than 24% of the total cash receipts from all livestock and crops in Florida (8), and 3) about 366,000 acres (3) and over 3,000 farmers (5) were involved in producing the 1970-71 vegetable crop.

Much of the importance of Florida's vegetable subsector¹ has been overlooked if the evaluation stops with farmers. The value of production given above reflects solely a farm level price paid upon delivery at a packing or preprocessing plant. Beyond local producing areas various processing and distribution activities add value to the product

¹A subsector is defined to include all of the activities involved in producing, harvesting, packing, processing and distributing an agricultural commodity or closely related group of commodities.