

Evaluation of Tropical Leaf Vegetables in the Virgin Islands

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Tropical leaf vegetables are grown in the tropics and are rich sources of nutrients, particularly minerals, and vitamins (Oomen and Grubben 1978). A number of species and cultivars have been introduced and grown in the continental US on a limited-scale, particularly in the southern region (Lamberts 1993). The US is a major market for tropical and specialty greens and most of the shipments come from the Caribbean and Latin America. For example, in 1998, total US imports for dasheen leaves (*Colocasia esculenta* L. Schott, Araceae) was over 90 t. From this total, 70% came from Jamaica and 30% from the Dominican Republic (Pearrow 1991). In the same year, the US imported amaranthus (*Amaranthus* spp. L., Amaranthaceae) at 27 t from the same countries. In 1988, shipments of Oriental, Mexican, tropical, and exotic produce, including specialty leafy greens, accounted for about 5% of fresh vegetable shipments, whereas in previous years the volumes have been too low to track (Cook 1990; Lamberts 1990, 1993).

There are several reasons for the increasing demand of tropical and specialty leafy greens in the US. Growth in ethnic populations contributes to demand for product diversity within the produce section (Cook 1990) and food, previously considered ethnic or regional in nature is increasingly being consumed by a broader portion of the population. This trend will likely continue as the ethnic population continues to grow and more Americans become familiar with and develop the taste for the new crops.

This research study is undertaken with the following objectives: (1) collect and describe growth characteristics of minor tropical leaf vegetables; and (2) evaluate yield performance and commercial potentials in the Virgin Islands and the Caribbean.

AMARANTHACEAE

Amaranth

Amaranthus spp. are common, short-lived annuals, the leaves of which are used as potherb. Some species are cultivated in home gardens and for marketing. Several species exist depending on the region in the tropics. For example, *A. tricolor* L. is mostly found in East Asia, while *A. cruentus* (L.) Sauer is common in Africa and *A. dubius* Mart. ex Thell. in the Caribbean. Amaranths are probably the most important leaf vegetables of the lowland tropics of Africa and Asia, but scarcely known in South America. The nutritional value is high where vitamins A and C, and calcium and iron are found in good quantity. However, the high oxalic acid content may decrease the availability of calcium (Oomen and Grubben 1978; Martin and Ruberte 1979). Boiling produces a very acceptable spinach. Some Indian cultivars are markedly short-day plants, so market growers plant them in the beginning of the summer and harvest over several months by repeated pruning until plants flower at the end of the season.

Amaranths are upright and branch sparsely. The leaves are relatively small (5–10 cm long) but quite variable among cultivars. The flowers are small, and are borne in abundance in terminal or axillary spikes. The seeds are born in large numbers, small and edible. The flowers are not edible. The leaves, petioles, and young tips are used in salads and as potherb.

Amaranth is a suitable plant in crop rotation. It is not affected by common soil diseases such as nematodes, fungal, and bacterial wilt. Serious pests and diseases are damping off, wet rot, caterpillars, and stemborers. Early flowering may occur as a consequence of a short daylength or as a result of a short period of water stress.

Considerable differences exist between the three main species. The African cultivars of *A. cruentus* are originally grain-amaranths. They have a long stem and a high dry matter content in the leaves and bear large inflorescence. *A. dubius* and *A. tricolor* cultivars have a much lower seed production and their habit is similar to spinach, with a short stem and succulent leaves. Commercial cultivars exist in India, Taiwan, the Caribbean, and the US.

Eight cultivars were evaluated at the experiment station during the summer-fall season of 1997. The cultivars consisted mainly of *A. tricolor* compared against the local amaranth (*A. dubius*). Most of them performed well in terms of plant establishment, but differed in seedling or plant vigor. Most of the *A. tricolor* cultivars had poor plant vigor and were susceptible to damage by cutworms and leafrollers (Lepidoptera: *Pyralidae*). They also produced seed head (bolting) early before producing considerable leaf area. The number of days from planting to first harvest ranged from 40 to 47 days (Table 1). Edible leaf fresh yield was highest (1158 g/m²) for amaranth cv. Callaloo and lowest (240 g/m) for amaranth cv. Greenleaf. It appears that 'Callaloo' is suitable for production in the Virgin Islands.

Celosia

Celosia (Celosia argenticia L.) is present in Africa and Asia both as a weed and as a cultivated leaf vegetable resembling amaranth. Some species and cultivars with a wide variation in leaf color are grown as ornamental plants. The vegetable type celosia is the most important leaf vegetable of Southern Nigeria and is popular in Benin, Zaire, and Indonesia. It is grown in home gardens and small farms both for home consumption and marketing. The plants are vigorous annuals that grow rapidly from seed. They are upright with alternate leaves and few branches until near flowering time. The flowers are borne in dense heads that yield large numbers of edible seeds. The flowers are often brilliantly colored, and the green foliage may contain large amounts of anthocyanin pigments. The leaves, young stems, and young flowers are eaten as a pot herb. Much of the pigment is lost on cooking, but the leaves retain a pleasant green color.

Three cultivars were evaluated during the 1997 spring season. *Celosia argenticia* cv. USA produced the highest yield and productivity (Table 1). *C. argenticia* cv. India and *C. argenticia* cv. Quailgrass have similar yield of edible leaves. All cultivars were resistant to pest and diseases. Celosia appears to be a good alternative leaf vegetable to local amaranth which is very susceptible to many insect pests.

Table 1. Yield and productivity of warm season tropical leaf vegetables in the Virgin Islands, Summer-Fall, 1997.

Common name	Botanical name	Days to first harvest	Edible leaf fresh wt. \pm SE (g/m ²)	Daily productivity \pm SE (g/m ²)
Amaranth				
Local	<i>Amaranthus dubius</i>	42	365 \pm 2.5	8.70 \pm 0.2
Tigerleaf	<i>Amaranthus tricolor</i>	41	455 \pm 2	11.1 \pm 0.1
Callaloo	<i>Amaranthus cruentus</i>	40	1158 \pm 15	29.0 \pm 0.4
Greenleaf	<i>Amaranthus tricolor</i>	47	240 \pm 7	5.1 \pm 0.2
Gangeticus	<i>Amaranthus tricolor</i>	41	295 \pm 12	7.2 \pm 0.3
Merah	<i>Amaranthus tricolor</i>	41	432 \pm 8.5	10.5 \pm 0.2
Pinang	<i>Amaranthus tricolor</i>	42	430 \pm 3	10.2 \pm 0.1
Puteh	<i>Amaranthus tricolor</i>	42	367 \pm 14	8.7 \pm 0.3
Celosia				
USA	<i>Celosia argenticia</i>	41	1604 \pm 584	39.1 \pm 14.2
India	<i>Celosia argenticia</i>	41	650 \pm 17	15.9 \pm 0.4
Quailgrass	<i>Celosia argenticia</i>	42	615 \pm 8	14.6 \pm 0.2
Bush Okra	<i>Corchorus olitorius</i>	43	735 \pm 18	17.1 \pm 0.4
Malabar				
Green	<i>Basella alba</i>	57	344 \pm 4.5	6.04 \pm 0.1
Red	<i>Basella rubra</i>	57	385 \pm 81.5	6.75 \pm 1.43
Sweet potato	<i>Ipomoea batatas</i>	42	821 \pm 98.0	14.7 \pm 1.8
Water spinach	<i>Ipomoea reptans</i>	57	412 \pm 68.0	7.23 \pm 1.2

BRASSICACEAE

Arugula

Arugula (*Eruca sativa* Mill.) is a low growing, annual leaf vegetable with dull green, deeply cut, compound leaves. The edible leaves are characterized by a distinctive spicy, pungent flavor resembling horseradish. The leaves are used in a young tender stage for salads and sometimes cooked as a potherb. The plant was considered by early writers as a good salad herb, but not to be eaten alone. Ancient Egyptians and Romans both have considered the leaves in salads to be an aphrodisiac. Arugula is a very minor crop in the US. In Florida, it is grown to a limited extent commercially and in home gardens where it seems to do quite well (Stephens 1988).

In the Virgin Islands, arugula grows best during fall planting, where it takes 61 days from planting to first harvest. Average edible fresh yield is 840 g/m² (Table 2). When grown during the hot summer months, arugula tends to produce flower heads (bolting) and susceptible to insect pest damage. It is a suitable leaf vegetable for the Virgin Islands where there is demand from local food stores, restaurants, and hotels.

Chinese Mustard

Chinese mustard [*Brassica juncea* (L.) Czern.], is a popular leaf vegetable in the Far East. In contrast to Chinese cabbage the petioles of mustard have no wings and are not swollen, instead the dented leaf blades are thin and crispy, and the taste is sharp. Some cultivars have a strong pungent taste. Leaves of Chinese mustard are deeply notched, narrow, and feathery. A single plant may have as many as 20–50 leaves clustered together in a compact bunch. Local mustard cultivars are used as leaf vegetables in tropical Asia. The leaves may be eaten raw, as in a salad. As a potherb it is prepared in many ways: as a steamed or boiled well-seasoned green, stir-fried, in soups, or mixed with other vegetables. Like other mustard, Chinese mustard is rich in vitamins and minerals.

Chinese mustard grows well when planted in the fall season in Virgin Islands. However, it is not as productive as the common mustard greens. Average edible leaf yield is only 5–10% of common mustard greens cvs. Florida Broadleaf and Savanna (Table 2). Nevertheless, Chinese mustard is a promising specialty crop in the Virgin Islands.

Pak Choi

Pak choi (*Brassica rapa* L. var. *chinensis*) is a very popular tropical leaf vegetable. It is a non-heading Chinese cabbage with prominent white, fleshy petioles and upstanding glabrous leaves forming a loose rosette as in swiss chard. The large leaves are glossy and dark green. Pak choi flowers and sets seed very easily at high temperatures and long days are favorable for flower development (bolting). It is a quick maturing plant which can be harvested 30 to 45 days after planting. Individual leaves or entire heads are harvested, used raw or cooked. The popularity of pak choi as a summer vegetable in temperate zones and as an all-year leaf vegetable in the humid tropics is increasing. In the Virgin Islands, it is one of the most productive leaf vegetables grown during the fall season with average edible leaf yield of 3577 g/m² (Table 2). It is being grown by many home gardeners in St. Croix and St. Thomas. It is seen in local markets and on farmers' market.

Table 2. Yield and productivity of cool season tropical leaf vegetables in the Virgin Islands, fall, 1997.

Common name	Botanical name	Days to first harvest	Edible leaf fresh wt. \pm SE (g/m ²)	Daily productivity \pm SE (g/m ²)
Arugula	<i>Eruca sativa</i>	61	840 \pm 14	9.2 \pm 0.2
Chinese mustard	<i>Brassica juncea</i>	38	451 \pm 42	12.9 \pm 1.2
Mustard				
Florida	<i>Brassica juncea</i>	33	2118 \pm 141	176.5 \pm 11.5
Savanna	<i>Brassica juncea</i>	34	4169 \pm 1612	720.5 \pm 105
Pak choi	<i>Brassica rapa</i> var. <i>chinensis</i>	38	3577 \pm 400	32.3 \pm 4.3
Komatsuna	<i>Brassica rapa</i> var. <i>perviridis</i>	51	3843 \pm 131	19.5 \pm 0.3

Komatsuna

Otherwise known as Japanese mustard, komatsuna (*Brassica rapa* L. var. *perviridis*) is an annual cool season leaf vegetable. The plant appears similar to common mustard, but grows faster and bigger than mustard. Leaves are broad and oval in shape with dark green color. It has the combined flavor of mustard and spinach and remains tender in dry and hot weather. It can be grown year-round and tolerates cold weather. It is the most productive leaf vegetable in the evaluation trial at the experiment station. It matures in 51 days after planting with average edible leaf yield of 3843 g/m² (Table 2).

BASELLACEAE

Malabar Spinach

Malabar spinach (*Basella* spp. L.) is also known as Ceylon spinach, vine spinach or Malabar nightshade. It is a climbing perennial plant, mostly cultivated as an annual vegetable against a support in home gardens but in some areas as a vine like market vegetable without staking. There are two common species of Malabar spinach, the red stem and leaves (*Basella rubra* L.) and the green leaves and white stem (*Basella alba* L.). Malabar spinach is not a true spinach (*Spinacia oleracea* L., chenopodiaceae), but its leaves, which form on a vine, resemble spinach, and are used in the same way. The plant is a native of the East Indies, and found its way to the New World from China. It has spread throughout the tropical world and it is one of the best tropical spinach widely adapted to a variety of soils and climates. It is particularly abundant in India, Malaysia, and the Philippines, but it is also seen throughout tropical Africa, the Caribbean, and tropical South America.

Malabar spinach has thick tender stems and the leaves are almost circular to ovate, alternate, and short petioled. They are thick, rugose, succulent, and colored from green to purple. The flowers, borne on axillary spikes or branching peduncles are bisexual and inconspicuous. The fruits are fleshy and purplish black and the juice is sometimes used as a dye.

The succulent young and mature leaves, and the stems are eaten. The most common method of cooking is as a pot herb, mixed with stew or other vegetables. On cooking, the green stem/leaf species retains its fresh green color. The red species loses much pigment to the water and is less attractive. The leaves have mild flavor or are almost tasteless. The stems may be somewhat bitter, and become gelatinous or mucilaginous especially when overcooked. Malabar spinach is a good source of vitamins A and C, calcium, and iron.

Malabar spinach is a perennial that tends to extend itself over time. Seeds can be sown directly or vines may be established directly from stem cuttings. These need a little shade on transplanting, but root readily. Malabar spinach can thrive under conditions of moderate soil fertility, but is quite responsive to nitrogen fertilizer. Evaluation trial at the experiment station indicated that plants can be harvested at 57 days after planting. The red species is slightly more productive than the green species (Table 1). Edible leaf yield was 385 g/m² for the red species compared to 344 g/m² for the green species. Malabar spinach is one of the rapidly growing tropical leaf vegetables in the Virgin Islands, responds well to pruning and nitrogen fertilizer. In addition, it is tolerant to insect pests and diseases. It is definitely one of the minor tropical leaf vegetables with market potential in the Virgin Islands.

CONVOLVULACEAE

Water Spinach

Water spinach, kangkong, swamp cabbage, or water convolvulus (*Ipomoea aquatica* Forsk., or *Ipomoea reptans* Poir) is an important green leaf vegetable in most of Southeast Asia. It is a trailing tropical lowland plant, related to sweet potato. Two main cultivar groups can be distinguished: var. *aquatica* and var. *reptans*. The first is an aquatic plant or paddy vegetable in the Southern part of India and Southeast Asia, propagated by cuttings and growing in the wild or cultivated in fish ponds and water courses. The second is an upland vegetable, cultivated on dry or marshy land and propagated by cutting or seeds. Both types are an important market vegetable in Malaysia, Indonesia, and other Southeast Asian countries. Several cultivars are known, but the most important distinction is between upland (dry) forms and paddy (swamp) forms.

Water spinach develops a trailing vine that spreads rapidly by rooting at the nodes. Vertical branches arise from the leaf axils. It is quite glabrous, with sagittate, alternate leaves. The leaves are somewhat succulent, particularly in the wet land form, and has a pleasant light green color. A white flower is produced which matures into a 4-seeded pod.

Almost all parts of the young plant are eaten. Older stems, especially from plants cultivated on dry land, contain considerable fiber. Therefore, cultural methods emphasize the production of young succulent tips. These can be eaten fresh in salads. Often they are cooked as spinach. The flavor is bland and some spicy ingredients or salt are added to enhance flavor. The leaves maintain much of their green color, but the stems are yellowish when cooked (Martin and Ruberte 1979).

Water spinach is planted either from seed or from cuttings. Seeds do not germinate well under water, but can be direct seeded. Plants are normally grown in nursery beds for later transplanting in the field. In evaluation trial conducted at the experiment station, the upland type of water spinach was harvested 57 days after planting. The average edible leaf yield was 412 g/m² (Table 1). Productivity was about similar with Malabar spinach. Under Virgin Islands climatic conditions, water spinach grows well during summer-fall season and is a suitable leafy green vegetable with market potential.

Sweet Potato

The leaves of sweet potato (*Ipomoea batatas* L.) are used as a potherb in Southeast Asia, the Pacific, and locally in Latin America. It is an important foodstuff for the highland population of New Guinea. Sweet potato leaves are considered as a cheap and coarse vegetable. Stems and leaves are used as forage. Often considered a poor man's food, sweet potato leaf has a rich protein content that helps fill the nutritional gap left by eating principally the protein-poor tubers. Sweet potato leaves are particularly important, and cultivars have been developed that are used only for the leaves. These cultivars are rich in calcium. However, cultivars differ in general appearance, flavor, and bitterness. Many cultivars have a resinous flavor that is acceptable unless quite strong.

Sweet potato merits a place in tropical gardens because it is easy to culture and yields edible tubers as well as leaves. Leaves and tubers can be produced year round and plants are adapted to a wide range in climatic conditions. Most soils are suitable for sweet potato, but soils rich in organic matter promote lush growth of leaves. Sweet potato is adapted to calcareous soils of the Virgin Islands. Leaves and young shoots can be harvested in 42 days after planting (Table 1). It is more productive than amaranth, Malabar spinach, and water spinach. Frequent harvest stimulates development of side shoots and vines. Although it is a perennial, its succulent nature restricts its cultivation to relatively short growing seasons of 3 to 5 months. It is definitely a suitable leaf vegetable for the Virgin Islands and a good alternative to local spinach.

TILIACEAE

Bush Okra

Bush okra, jew's mallow, or jute mallow (*Corchorus olitorius* L.) is primarily known as a fiber crop, however, special types with shorter and more branched stems are frequently cultivated as a mucilaginous tropical leaf vegetable. Bush okra is one of the popular tropical leaf vegetables in Africa, Asia, and some parts of the Middle East. The plant belongs to the Tiliaceae and is characterized as an annual upright, branching, glabrous, slightly woody herb. Leaves are narrow and serrate, about 5–13 cm in length. Flowers are small, yellow-petioled, and borne in small clusters in the leaf axils. The cylindrical capsules of 2–5 cm are produced in large numbers, especially during the short days (Martin and Ruberte 1979). Seeds are dark bluish-green, angular, and about 2 mm long.

Bush okra is one of the leading leaf vegetables in West Africa and is often stored dry. It is also commonly used in Malaysia, the Philippines, and parts of Latin America. It is the most important leaf vegetable in Egypt, where it is cultivated from March to Nov. (Oomen and Grubben 1978). The nutritional value of bush okra compares very well with other common tropical leaf vegetables. It is high in protein, fiber, calcium, iron, and carotene. The edible shoot tips and leaves are always eaten and cooked as a potherb. Their edible quali-

ties are widely appreciated in West Africa where the shoots and leaves are combined in stews to be eaten as a starchy paste. In India the shoots are cooked with rice.

Although bush okra is a popular leaf vegetable in many countries of the tropics, little research and development work have been done to improve its culture and production. According to Oomen and Grubben (1978) seed yields of bush okra are low, and germination is often very poor due to dormancy which can be overcome by soaking in hot water. Leaf production is also low compared to other tropical leaf vegetables, but dry matter content is high. Trials at the experiment showed that bush okra can be harvested in 33 days after planting, however, edible leaf yield is very low (Table 1). Yield and productivity can be increased by increasing planting density. Studies by Palada and Crossman (1998) indicated that a planting density of 98,522 plants/ha or a plant spacing of 50 × 20 cm was optimum for maximum yield of bush okra. Bush okra is resistant to damage by pests and diseases. It is one of the most suitable leaf vegetables for growing in the Virgin Islands.

SUMMARY

The germplasm evaluation trials indicate that under Virgin Islands conditions, most of the cool season *Brassica* spp., including the Oriental greens show potentials for adaptability and higher productivity. The warm season species such as the Malabar spinach, celosia, and sweet potato performed better than amaranth, bush okra, and water spinach. Planting density study with bush okra indicated that yield and productivity can be increased with closer spacing. Crop management trials involving plant spacing and fertilizer application are on-going to improve the yield of the common species including amaranth, Malabar spinach, celosia, and water spinach. When outstanding species and cultivars are identified and improved cultural management practices are developed, local growers will be able to adopt these recommendations to enhance production of tropical leaf vegetables. Future efforts will be focused on product development and marketing of these specialty vegetables.

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