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GERMPLASM EVALUATION PROJECT FOR TROPICAL LEAF VEGETABLES AT THE UNIVERSITY OF THE VIRGIN ISLANDS

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ABSTRACT. The increased consumption of new and exotic vegetables of tropical origin such as dasheen (*Colocasia esculenta* L. Schott.) and amaranth (*Amaranthus spp.*) has stimulated great interest for research on these crops. Tropical and specialty green leaf vegetables are a major group of horticultural crops that have been the focus of attention in national symposia on new crops. The U.S. imported significant amounts of tropical green leaf vegetables during the past 5 to 8 years, and this trend will likely continue. Some of these crops can be grown in the U.S., but factors such as scarcity of seeds and planting materials coupled with inadequate information on cultural management practices limit the production of these crops in the U.S. The University of the Virgin Islands has initiated a research project to collect and evaluate germplasm of tropical leaf vegetables with market potential. The approach of this project includes: 1) germplasm collection and evaluation; 2) development of sustainable crop management and cropping systems and 3) conservation and maintenance of germplasm materials. Preliminary field evaluation trial indicates that Malabar spinach (*Basella spp.*); water spinach (*Ipomoea aquatica* Forsk.); potato greens (*Ipomoea batatas* L., Lam.); and jute mallow (*Corchorus olitorius* L.) showed potential yields comparable to yields of common leaf vegetables such as collard (*B. oleracea* L., Acephala); and mustard green (*B. juncea* L., Czerniak). Multiple harvests from these crops during the growing season resulted in fresh edible yields ranging from 3.22 to 52.0 g m^{-2} day^{-1}.

INTRODUCTION

Tropical and specialty green leaf vegetables are one of the major groups of horticultural crops that have been featured in the new crops symposia during the past five years (Janick and Simon, 1990; 1993). The proceedings from these symposia indicate that new and exotic tropical horticultural crops including leaf vegetables are becoming important in the United States and will somewhat change the focus and emphasis of food production in the next decade.

Tropical leaf vegetables are commonly grown in the tropics and are rich sources of nutrients, particularly minerals and vitamins. A number of species and cultivars have been introduced in the U.S. on a limited scale, particularly in the southern region (Lamberts, 1993). The U.S. is a major market for tropical and specialty greens and most of the shipments come from the Caribbean and Latin America. For example, in 1988, total U.S. imports for dasheen leaves was over 90 metric tons. From this total, 70% came from Jamaica and 30% from the Dominican Republic (Pearrow, 1991). During the same year, the U.S. imported 27.4 metric tons of vegetable amaranth from the same countries. Additionally, 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 had 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 U.S. One is that, growth in ethnic populations contributes to the demand for product diversity within the produce section (Cook, 1990). Food previously considered ethnic or regional in nature increasingly are 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.

Tropical leafy greens include plants with a wide variety of germplasm. Leaves of these plants are used mainly for culinary purposes or as pot herbs. Some species have medicinal value and are, therefore, used to remedy certain diseases. Their greatest contribution to human nutrition is their high contents of essential minerals and vitamins. When consumed daily, they provide adequate amounts of the daily requirement for vitamins and mineral for adults and young children.

Tropical leafy greens have their origin in tropical Africa, Asia, the Caribbean and Latin America. In these regions, they are grown in home gardens and on small to medium scale farms. Some of the popular tropical leafy greens include celosia (*Celosia argentia* L.), Malabar or Ceylon spinach, kangkong or water green, jute or jews mallow, moringa (*Moringa oleifera* Lam.) and chaya (*Cnidoscolus chayamansa* McVaugh) in addition to dasheen and amaranth mentioned above.

Research and development efforts on crop improvement and improved production practices for these crops have been minimal. These crops are considered minor vegetables and therefore, research studies are given low priority. As demand for tropical leafy greens increases, the need for information on crop production and post harvest practices will increase. This will be a great challenge for researchers as well as farmers. Also, there is a need for conserving the germplasm of these crops. One of the

factors limiting the production of these crops in the U.S. is the scarcity of seeds and planting materials.

The U.S. Virgin Islands has an ideal climate for growing tropical green leaf vegetables. Production of tropical, exotic and specialty green leafy vegetables offers economic opportunities and advantages and can contribute to the economic growth of the Virgin Islands. As alternative and new crops, tropical and specialty greens will have good market potential to meet increasing demands in the U.S. mainland. Growers will have a better market advantage in producing these crops and shipping them to specialty markets in the U.S. compared to growing traditional vegetables such as tomatoes, peppers, eggplant, since they cannot match the low market price of these vegetables coming from the U.S. mainland.

The objectives of this project are: 1) to collect and evaluate germplasm of minor tropical green leaf vegetables in terms of plant growth characteristics and yield potentials; 2) to evaluate response of germplasm materials to growing environmental conditions including pest and disease pressures; 3) to develop sustainable crop management practices and cropping systems for improving yields of tropical leaf vegetables with market potential in the U.S.; and 4) to maintain germplasm of promising species and cultivars of exotic tropical leaf vegetables for future studies on crop improvement and development.

PREVIOUS AND RELATED CURRENT RESEARCH

For the past 20 years, little research have been done on tropical and specialty leaf vegetables. Several books and manuals were published in the 70s and 80s covering information and literature on tropical leafy greens. Among the few relevant references are those published by Dupriez and De Leener (1989); Herklots (1972); Martin and Ruberte (1979); NAS (1975); Oomen and Grubben (1978); Stephens (1988); Tindall (1983); and Yamaguchi (1983). Most information covered in these publications deal with botanical description, cultivation and utilization of these crops. There are other valuable sources of information on tropical leaf vegetables prior to 1970 which were cited by above-mentioned authors. Few published journal articles exist dealing with research on crop improvement and cropping systems for tropical leaf vegetables. Recent interest on new crops in the U.S. will encourage and stimulate researchers to conduct more project studies on tropical leaf vegetables.

Germplasm: At present no single organization devotes its program solely for germplasm collection and evaluation of tropical leaf vegetables. The International Genetic Resources Institute (IPGRI) has published a directory of germplasm collection for vegetables including amaranths (Bettencourt

and Konopka, 1990), but does not include other minor tropical leaf vegetables. Availability of germplasm is limited for these crops and gene banks in the U.S. may have some collections of a few genera and species. Germplasm materials for specific tropical leaf vegetables are only available in countries where they are commonly grown. Oomen and Grubben (1978) listed about 50 genera and species, whereas, Martin and Ruberte (1979) reported more than 400 species. A large number of species exist in Africa, while in Southeast Asia, Indonesia is one of the richest sources of tropical leaf vegetables. In Africa, Dupriez and De Leener (1989) listed 25 popular species including cool season types.

Tropical leafy greens are classified according to plant type, use and importance (Martin and Ruberte, 1979). Based on plant type, they are described as herbaceous, viny, shrubby, arboraceous, annual and perennial. Classification by use includes salad, garnish, relish, pot herb, and condiment. Oomen and Grubben (1978) classified tropical leaf vegetables into four major groups: annual hot season, annual cool season, perennial, and leaves of food crops grown for other purposes. This classification is arbitrary since a given species can fall under two or more groups.

According to Oomen and Grubben (1978), good seeds of tropical leaf vegetables are hardly ever available in the tropics. They reported that only in India is a well-organized seed industry for important species has been set up. Market growers of tropical leaf vegetables must be advised to harvest their own seeds from the most vigorous and best quality plants and to clean and dry them well before use. Similarly, cuttings of vegetatively propagated vegetables such as bitterleaf (*Vernonia amygdalina* Del.), chaya, cassava (*Manihot esculenta* Crantz) and kangkong, are not commercially available, therefore, growers must acquire them from a local source.

Breeding for Crop Improvement: There has been little breeding work done for the improvement of minor topical leaf vegetables. Being a group of minor crops, less attention has been focused on improving plant types and cultivars. Traditional books and manuals only give general classification, including botanical names, origin, plant types, varieties, utilization and cultural management practices for tropical leaf vegetables (Martin and Ruberte, 1979; Oomen and Grubben, 1978). Vegetable breeding in the tropics has been focused on important crops like tomatoes, peppers and cabbages (Winters and Miskimen, 1967). Most of the vegetable improvement investigations has been conducted by agencies of various governments as well as international research centers and private corporations. Reviewing the past breeding programs of these agencies indicates that emphasis is given to major vegetable crops with economic importance. Like many vegetable crops, tropical leaf vegetables are also

subject to high pressures of pests and diseases. An extensive, coordinated vegetable breeding program is greatly needed for tropical leaf vegetables to develop cultivars with climatic adaptation that will resist the insects and diseases present in a particular agro-ecological region.

Most of the studies related to crop improvement for tropical leaf vegetables were related to cultivar evaluation, and a number of studies were carried out for vegetable amaranth (Grubben, 1980; Martin and Ruberte, 1977; Martin and Telek, 1984; Sealy *et al.*, 1990). Selection of cultivars for local conditions has been done in India, Puerto Rico, Benin, and Nigeria, but very little has been accomplished towards breeding for better cultivars (Martin and Telek, 1984). Not much has been done on cultivar screening for other leaf vegetables such as celosia, jute mallow and water spinach. Research has been done in the U.S. on cultivar evaluation for cool season Oriental greens such as Chinese cabbage, pak choy, and related species in the brassica family (Coffey and Disney, 1992; Fo *et al.*, 1993; Palada, 1984; Palada *et al.*, 1987). These studies have identified suitable cultivars for production in the northern and southern U.S.

Crop Management: A wealth of information on crop management practices for growing tropical leaf vegetables is available from several books and manuals (Dupriez and De Leener, 1989; Harrington, 1978; Herklots, 1972; Knott and Deanon, 1976; Martin and Ruberte, 1979; Oomen and Grubben, 1978; Stephens, 1988; Tindall, 1965; Winters and Miskemen, 1967; and Yamaguchi, 1983). These references provide excellent discussion on cultural practices from seedling establishment or vegetative propagation by stem cuttings to plant spacing, fertilizer application, and harvesting. Information is also given on climatic and soil requirements for each species and pest and disease associated with crops. Recommended cultural practices and yield of some tropical leaf vegetables have been reported by AVRDC (1985) and by Oomen and Grubben (1978). Although recommended crop management practices are mentioned for each crop, these recommendations are general and may not always apply to a specific location. Site specific studies are needed especially on plant population density, fertilizer levels, water use, cropping systems and pest management. Singh and Whitehead (1993) studied the effects of plant density and soil pH on vegetable amaranth production and concluded that yield increased quadratically as intra-row spacing decreased. Growth was adversely affected by soil pH below 6.4. There is also a need for research on developing sustainable crop management practices and cropping systems as most of these vegetables are grown under low-input management systems in the tropics.

Pest Management: The most common damage in tropical leaf vegetables is caused by insects feeding on leaves, generally caterpillars (Oomen and Grubben, 1978). These pests not only hamper growth and yield, but they also damage the leaves, reducing the quality, attractiveness and market value of the crop. The application of chemical insecticides is generally the most efficient way for market gardening, but their use implies risk to health and the environment. Studies on environmentally sound pest control methods for tropical leaf vegetables are needed, especially with recent availability of less toxic bio-organic pesticides. Wilting is a common disease of tropical leaf vegetables caused by fungi and bacteria while root knot nematodes frequently cause swellings and nodules on the roots resulting in retarded growth. Both diseases can be controlled by sound cultural practices such as good soil drainage, fertilizer application and crop rotation. So far, not much studies have been done on these practices for tropical leaf vegetables.

APPROACH

Germplasm Collection and Evaluation: The emphasis of germplasm collection and evaluation will be directed towards minor tropical leaf vegetables. Seeds or planting materials will be collected for the following groups as shown in Table 1a to 1d. Germplasm collection for these crops will be conducted in several ways: 1) local survey, inventory and collection, 2) orders through seed catalogs and seed companies carrying specialty vegetable crops, 3) sending requests to various seed/gene banks and repositories in the US and abroad, 4) sending requests to other institutions conducting studies on tropical greens, e.g. universities, private and non-governmental agencies, and international agricultural research centers including the IPGRI and Caribbean Agricultural Research Institute (CARDI). These organizations will be contacted via e-mail or through the internet.

Table 1a. Annual Warm Season Tropical Leaf Vegetables for Collection and Evaluation.

Botanical/Scientific Name	Common/English Name
Amaranthus spp.	Vegetable amaranth, amaranthus
Basella spp.	Ceylon spinach, Malabar spinach
Celosia argentia	Celosia
Colocasia esculenta	Taro, Calalou
Corchorus olitorius	Jute/Jews Mallow, Bush okra

Continuation Table 1a. Annual Warm Season Tropical Leaf Vegetables for Collection and Evaluation.

Botanical/Scientific Name	Common/English Name
Hibiscus sabdariffa	Roselle
Ipomoea aquatica	Kangkong, Water spinach
Ipomoea batatas	Sweetpotato greens
Rumex abyssinicus	Sorrel
Solanum nigrum	African eggplant, Nightshade
Spilanthes acmella	Paracress
Talinum triangulare	Water leaf

Table 1b. Annual Cool Season Tropical Leaf Vegetables for Collection and Evaluation.

Botanical/Scientific Name	Common/English Name
Brassica alboglabra	Chinese broccoli
Brassica campestris Chinensis Group	Pak Choi
Brassica carinata	African leaf cabbage
Brassica juncea var. rugosa	Chinese green mustard
Beta vulgaris	Spinach beet
Chenopodium album	Pigweed
Chrysanthemum coronarium	Garland chrysanthemum
Cichorium endiva	Endive
Nasturtium officinale	Watercress
Portulaca oleracea	Purslane
Spinacia oleracea	Spinach
Tetragonia expansa	New Zealand spinach

Table 1c. Perennial Tropical Leaf Vegetables for Collection and Evaluation.

Botanical/Scientific Name	Common/English Name
Cnidoscolus chayamansa	Chaya, Tree spinach
Gnetum gnemon	Gnetum
Manihot esculenta	Cassava
Morinda citrifolia	Indian mulberry
Moringa oleifera	Drumstick, horseradish
Nothopanax scutellarium	Nothopanax
Sauropus androgynus	Sauropus, katuk
Sesbania grandiflora	Sesbania
Telfairea occidentalis	Fluted Gourd
Vernonia amygdalina	Bitter leaf

Table 1d. Leaves of Tropical Vegetables Grown for Other Purposes.

Botanical/Scientific Name	Common/English Name
Capsicum annuum	Sweet pepper, bell pepper
Cucurbita moschata	Tropical pumpkin, calabaza
Momordica charantia	Bitter gourd, bitter cucumber/melon
Psophocarpus tetragonolobus	Winged bean
Sechium edule	Chayote
Vigna unguiculata var. sesquipedalis	Yard long bean

When seeds and planting materials are received they will be grown in the greenhouse and later planted in the field for observations. Data will be collected on growth habit, maturity, reaction to pest and diseases and potential yields. Some plants will be left in the field and observed for seed production. When enough seeds are collected, replicated plots will be established for further investigations. Field evaluation will be carried out for species with several cultivars in variety trials.

Development of Sustainable Crop Management and Cropping Systems:

Under this objective the following studies will be conducted. 1) effect of plant spacing and population density on yield; 2) growth and yield response to organic and synthetic fertilizers; 3) microirrigation for efficient water use; and 4) intercropping and crop rotation studies. Optimum plant spacing and density will be determined for selected species from each group. Plants will be planted at various row spacing and standard spacing suggested in books and manuals will be used as control. Trials will be conducted to determine optimum fertilizer requirement for these crops using animal manure and synthetic slow release fertilizers. Likewise, minimum water requirement for selected species will be determined using microirrigation. Field trials will be established to determine efficient water use for selected species. Crops will be drip-irrigated at various levels based on soil moisture tension. This will be combined with mulching to further determine the most efficient level of drip irrigation.

In small farm systems, tropical leaf vegetables are commonly grown in mixed and multiple cropping systems. There are many benefits in these systems and one important advantage is the maintenance of biological stability through crop diversity. Pest and disease levels are lower in polyculture systems than in monoculture. Selected species of annual leaf vegetables will be intercropped with perennial types and total productivity will be determined in terms of land equivalent ratio. Separate trials will be conducted on crop rotation involving legume cover crops and other green manures. In all studies, weeds, insects, and diseases associated with the crops will be monitored.

Conservation and Maintenance of Germplasm Materials:

The ultimate objective of this project is to conserve and maintain the germplasm materials of the most promising types and species of tropical leaf vegetables. Species and cultivars with desirable characteristics, e.g. high yields and resistance to pest and diseases will be selected and propagated by seed and vegetative materials. This will be accomplished initially in the nursery and greenhouse. When enough seeds are produced, large scale seed production and multiplication will be carried out in the field. A modest supply of seeds and planting materials will be maintained continuously and will be reserved for future research work.

YIELD PERFORMANCE OF SELECTED ANNUAL WARM SEASON TROPICAL LEAF VEGETABLES: PRELIMINARY OBSERVATIONS

An observational field trial was conducted in the spring season of 1996 to evaluate yield performance of eight annual warm season tropical leaf vegetables. The species evaluated were: amaranthus (*Amaranthus cruentus*), collard green (*Brassica oleracea Acephala* cv. Vates), Jute mallow (*Corchorus olitorius*), red and green Malabar spinach (*Basella spp.*), mustard green (*Brassica juncea* cv. Florida Broad Leaf), pak choi (*Brassica rapa Chinensis* cv. Lei Choy), water spinach (*Ipomoea aquatica*), and sweetpotato greens (*Ipomoea batatas*). Seedlings or stem cuttings were transplanted on unreplicated 2-row plots at 6 m long. Row spacing was 50 cm while plant spacing within rows was 30 cm. Plants were drip-irrigated to ensure good establishment. Plots were fertilized with 200 N, 100 P_2O_5 and 100 K_2O in kg ha^{-1}. Fifty percent of N applied was from cow manure (2% N).

Yield samples were harvested from a 5 m section of each row. For species with running vines or stems, samples were harvested by cutting stems 10-15 cm from the base of the plant. Leaves were separated from stems and weighed to obtain fresh edible yield. For all other species, mature leaves were sampled periodically.

Table 2 presents data on number of days to first harvest, number of harvests, fresh yield of edible leaves and productivity. As shown in Table 2, mustard green and jute mallow had the shortest number of days to first harvest (32 and 33 days, respectively), while collard green took 63 days from planting to first harvest. The highest yield of edible leaves was produced by Pak choi (3131 g m^{-2}), followed by mustard green (1269 g m^{-2}). These two species also have the highest productivity as expressed in yield per unit area per day. The lower yield and productivity of species with running vines or stems such as malabar spinach, water spinach, and sweetpotato compared to non-viny species (Pak choi, mustard and collard greens) can be attributed to smaller sized leaves and slower rate of growth.

All species showed little damage due to insect pest or disease which suggests that these crops may require low levels of crop protection. The preliminary data indicate that tropical leaf vegetables are adapted to the growing conditions of the Virgin Islands and produce fresh edible yields within 1 to 2 months.

Table 2. Yield and productivity of some tropical leaf vegetables in the Virgin Islands, Spring, 1966.

Common Name	Days to First Harvest	No. of Harvest	Fresh Yield of leaves (g m^{-2})	Productivity (g m^{-2}/day)
Amaranthus	42	1	365	8.70
Malabar (red)	57	1	385	6.75
Malabar (green)	57	1	344	6.04
Mustard	32	3	1269	25.9
Collard	63	1	532	8.44
Pak choi	42	3	3131	52.0
Jute mallow	33	1	106	3.22
Water spinach	57	1	412	7.23
Sweetpotato	42	2	821	14.7

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