EDIBLE LEAVES OF THE TROPICS

2nd Edition

by Franklin W. Martin and Ruth M. Ruberte
Mayagüez Institute of Tropical Agriculture

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FOREWORD

Under tropical conditions, green leaves are everywhere, providing that soil and water conditions are not limiting. These leaves can be considered as highly organized factories that convert local crude materials, carbon dioxide, water, and minerals, to food. Green plants are the beginning of the food chain, and on them depends the life of other terrestrial organisms. Man, as an example of an advanced or predator species of the food chain, would be sorely pressed in the absence of green leaves.

Green leaves in the tropics serve as direct food sources to man under the most civilized circumstances. The important species are grown and preserved on both home and commercial scales. In primitive areas green leaves from wild plants are used as regular and important items of the diet. In times of emergency green leaves provide nutritious and readily available sources of food. Yet, these usages hardly touch on the potentials that exist in most environments. The green factories are underutilized and neglected, or depreciated and destroyed.

Among the reasons for such neglect are ignorance and prejudice. Both conditions are hard to cure. Because many people live in cities, they have not had the opportunity to try the wild herbs and other green leaves around them. The special knowledge often in the hands of a few wise members of the tribe or society is not regularly passed down to the younger generations. Furthermore, as dependence on market products increases, wild or weedy plants become despised. In the interests of marketing, only a limited number of species are propagated on a scale sufficiently grand to permit economy of handling operations. As pressures on the land increase, there is a growing danger of extermination of minor species. Furthermore, experimentation ceases. The grand total of human knowledge can then decrease. Without doubt, some local usages have already disappeared, and not even written records are left.

Lost in this historical process are the techniques for discovering new vegetables. Surely usages were revealed only through experimentation. There must always have been those who looked for, cooked, and ate new leaves for the excitement of discovery. In the process, the poisonous species were eventually discovered, the irritating types avoided, and the obnoxious rejected. In isolated areas, interests may be maintained or restimulated. During the Nigerian civil war, for example, starvation stimulated new experimentation in the bush, the results of which will probably be lost again rapidly.

Nevertheless, a new breed of explorers has arisen, those who are disenchanted with the bland products of the supermarkets, those who still feel the primordial urge to plant, those whose tastes are adventurous. There are also those whose pocketbooks are thin who can benefit from green leaves easily grown at home. Finally, there are the few who recognize that the vegetables we emphasize now are but a part of a larger, and mostly still available heritage, a heritage whose potentials have still not been fully realized.

It is to the lovers of edible green leaves that we dedicate this book.

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INTRODUCTION

The Place of Green Leaves in the Diet

Green leaves are not equally appreciated in all parts of the tropics and thus play a varied role in the diets of distinct peoples. East African and West African peoples make frequent use of green vegetables. On the island of Puerto Rico green leaves are considered food for animals. In the temperate zone lettuce is king and is invariably used uncooked as salad. Crucifers of many kinds are also well-known and widely used. Thus, the place of green vegetables in the diet is largely a matter of culture, training, and habit.

The place of green leaves in the diet may be considered from another standpoint, how the green food is used. Probably the most common use in all parts of the world is as a boiled vegetable. Such usage is very sound for potential pathogens are thus eliminated, sometimes poisonous or irritating substances are neutralized, and spoilage is brought to a halt. Nevertheless, this technique reduces the leaf to a limp and soggy mass, which may not always be appetizing. Some nutrients may be destroyed by heating while others may be leached out. As a general rule cooking should be as brief as possible. Some leaves may contain mucilaginous substances, which are often, but not always, appreciated. Frying leaves in oil or enveloped in batter preserves some of their unique characteristics and maintains their texture.

Many green leaves may be eaten raw, but some knowledge and judgement must be applied. Leaves of *Xanthosoma brasiliense* contain irritating calcium oxylate crystals, easily removed by boiling. Leaves of cassava (*Manihot esculenta*) contain dangerous hydrocyanic glucosides, inactivated by cooking. Raw vegetables add novel touches and serve to vary and make interesting the meal.

The drying of green leaves and their preservation as powder is a common enough practice in Africa and elsewhere. While it undoubtedly is often convenient, and permits storage of easily perishable leaves, some of the food value is lost in the drying process. Drying merits more investigation, however, for it is a simple technique that can be widely used throughout the tropics, especially using easily constructed and efficient solar dryers.

Nutritional Aspects

Many diets of the temperate and tropical zones are based on starchy staples supplemented, when possible, by foods high in protein. The green-leaved vegetables offer enrichment to such diets and are physiologically useful as regulators of the digestive tract. Greens also add vitamins and minerals quite out of proportion to their weight.

Green leaves are the most physiologically active parts of the living plant, and as such are usually rich in vitamins and minerals. Carbohydrate content of leaves is usually insignificant. Although leaves are often not rich sources of protein, some contain sufficient to supplement an otherwise inadequate starchy diet.

Vitamin A is generally found in rich quantities in leaves, especially dark green leaves (Table 1). Vitamin C is often present in appreciable

amounts. Riboflavin occurs in abundance and thiamine is also present in reasonable quantities. Vitamin A is somewhat resistant to the effects of cooking, but vitamin C tends to be destroyed. The B vitamins are partially soluble in water, and can be lost if the cooking water is discarded.

TABLE 1.—Vitamin content of some temperate and tropical edible green leaves[4]

Species	International Units per 100 g.			Sherman units per 100 g.
	Vit. A.	Vit. B_1	Vit. C	Vit. B_2
Beet greens	-	-	-	250
Broccoli leaves	21,000	16	-	275
Cabbage head	0	12	550	40
Chard	12,000	-	-	-
Collard	3,150	15	1,000	100
Dandelion	17,500	-	-	-
Dock	13,250	-	-	-
Endive	-	-	200	-
Escarole	14,000	-	100	95
Kale	21,000	12	-	200
Lambsquarters	10,000	-	-	-
Lettuce	2,800	9	80	50
Parsley	52,500	-	1,500	-
Spinach	17,500	15	800	125
Turnip greens	-	15	1,000	300
Watercress	-	15	1,000	100

[4] Daniel and Munsell: 1937.

The minerals of importance in green leaves (Table 2) are iron, calcium, and phosphorous. Some doubt exists, however, of the availability of these minerals to the human body. Calcium, for example, is not soluble as an oxylate, and thus is not taken up in the digestive tract.

TABLE 2.—Percentages of certain of the mineral elements in temperate and tropical edible green leaves*

Species	Calcium	Magnesium	Potassium	Sodium	Phosphorus	Chlorine	Sulfur	Iron
Beet greens	0.134	0.113	-	-	0.039	-	-	0.0032
Broccoli leaves	0.314	0.041	0.374	0.064	0.066	-	-	0.0024
Cabbage head	0.045	0.012	0.294	0.032	0.028	0.039	0.067	0.0004
Cabbage greens	0.429	0.034	0.402	0.065	0.072	0.108	0.07	0.0018
Celery	0.072	0.027	0.291	0.130	0.046	0.137	0.022	0.0007
Chard	0.104	0.053	0.318	0.086	0.050	0.039	0.124	0.0031
Collards	0.202	-	-	-	0.074	-	-	0.0016
Dandelion	0.113	0.036	0.461	0.168	0.041	0.099	0.17	0.0030
Endive and Escarole	0.074	0.013	0.381	0.060	0.038	0.071	0.032	0.0017
Kale	0.181	0.037	0.387	0.052	0.067	0.122	0.115	0.0025
Lettuce	0.054	0.011	0.311	0.030	0.031	0.073	0.018	0.0011
Parsley	0.193	-	-	-	0.084	-	-	0.0043
Spinach	0.083	0.055	0.489	0.084	0.048	0.065	0.027	0.0034
Turnip tops	0.254	0.019	0.307	0.045	0.058	0.092	0.054	0.0035
Watercress	0.168	0.028	0.301	0.080	0.041	0.109	0.147	0.0026

* Sherman, 1941

The protein of green leaves varies considerably. That of some green leaves such as kale and lambsquarters (Table 3), and cassava leaf (Table 4) approaches a significant level. Highest protein contents of leaves are found in certain shrubby species including *Poinsettia*, *Gnetum*, and *Moringa* (Terra, 1966). Knowledge of the protein contents of important tropical green leaves can be useful in balancing the diet. The amino acids of green-leaved vegetables also vary (Table 4). As sources of the usually short sulphur bearing amino acids methionine and cystine, the horseradish tree, *Moringa oleifera*, grown for edible leaves, shoots, young fruits, and roots, is incomparable. The leaves of cassava (*Manihot escalenta*) are also a good source of these amino acids. In contrast the edible roots contain very little.

TABLE 3. Protein, fat, and carbohydrate composition of some temperate and tropical edible green leaves*

Species	Protein (N X 6.25)	Fat	Carbohydrates Sugars	Carbohydrates Starch
	Percent	Percent	Percent	Percent
Amaranth	3.0	0.6	-	0.5
Beet greens	2.0	.3	0.5	-
Cabbage	1.4	.2	3.5	-
Cassava	8.2	1.2	3.3	-
Celery	1.3	.2	1.2	-
Chard	2.6	.4	.8	.1
Chayote	3.2	.7	1.1	-
Chinese cabbage	1.4	.1	.9	.2
Corn salad	2.0	.4	-	-
Cress	4.2	1.4	-	-
Dandelion	2.7	.7	.7	.2
Endive	1.6	.2	-	-
Kale	3.9	.6	1.2	0.2
Lambsquarters	3.8	.7	.3	1.4
Lettuce	1.2	.2	1.6	-
Mustard greens	2.3	.3	0.4	-
Nettle	5.5	.7	-	-
New Zealand spinach	2.2	.2	.6	0.3
Parsley	3.7	1.0	-	-
Purslane	1.6	0.4	-	-
Spinach	2.3	.3	0.3	-
Sweet potato greens	2.3	.3	-	-
Turnip greens	2.9	.4	-	-
Watercress	1.7	.3	-	-

* Chatfield and Adams, 1937, and other sources.

TABLE 4.—Amino acids of leaves of selected green leaf vegetables, expressed as mg per 100 g*

Species	Isoleucine	Leucine	Lysine	Methionine	Cystine	Phenylalamine
Bitter leaf	218	372	196	80	-	260
Cassava	339	900	437	118	77	386
Celosia	98	175	126	42	46	120
Surinam spinach	73	125	75	30	32	103
Horseradish tree	385	688	476	164	148	483
Kangkong	116	208	144	60	-	192
Hibiscus	176	305	217	54	74	200
Amaranth	218	359	234	96	74	255
Spinach	106	208	159	46	36	133
Ceylon spinach	54	103	89	20	27	87

Species	Tyrosine	Threonine	Trytophan	Valine	Arginine	Histidine
Bitter leaf	170	218	-	265	255	85
Cassava	274	327	102	401	381	157
Celosia	106	109	-	129	115	50
Surinam spinach	51	71	-	102	81	34
Horseradish tree	-	368	-	491	491	181
Kangkong	112	132	52	160	224	76
Hibiscus	132	186	-	225	193	85
Amaranth	172	197	57	256	213	94
Spinach	110	116	-	133	139	56
Ceylon spinach	49	56	-	67	72	40

* Food Policy and Food Science Service, FAO, 1970.

In Table 5 the nutritive values of green leaves are compared to those of other tropical vegetables and fruits, according to Terra, 1966. This table emphasizes the good protein and vitamin content of green leaves as compared to those of any other vegetables.

Three considerations in addition to taste preferences ought to influence the choice of foods for a normal diet, the caloric requirement, the protein requirement, and the need for vitamins and minerals. Leafy vegetables are particularly important with respect to the latter requirement, and indeed no other class of edible plants is equally rich in vitamins and minerals. The diet should include green leaves every day.

One other point should be mentioned in connection with the place of green leaves in the diet. Many of these foods taste good. People accustomed to the flavors of a few green leaves will find enchantment in the wider range of edible leaves available.

Classification of Green-Leaved Vegetables

The bewildering diversity of nature and the need to simplify it for our limited minds may well be the source of the urge to classify. Edible green leaves occur in such abundance that some classification is necessary, and contributes to the orderly treatment of these plants. Classification permits the rapid choice of particular leaves for special purposes. It also serves to satisfy a sense of orderliness.

But how to classify? In this book green leaves are classified principally by conventional taxonomy into families. To any student of botany this classification is meaningful. From the family one can often obtain a rough idea of the nature of the plant and at times of the characteristics of the leaf. Nevertheless, the conventional taxonomic system is a bulky apparatus, carried, as it were, by a frail body. Other classifications are useful in further characterizing the plant, and are used in developing the chapters, and in the descriptions later.

Classification by Plant Type

When green-leaved vegetables are classified by plant type (herbaceous, viny, shrubby, arboraceous, annual, or perennial) useful information is immediately conveyed. Useful appended information may suggest season of production of edible leaves, effects of daylength on flowering and seeding, and physiological limitations. Such information is indispensable to the gardener.

Classification by Use

Green leaves are used in a variety of ways that make easy classification possible. *Salad* vegetables are those that are normally uncooked as a side dish. However, if used principally to decorate the food, and not necessarily eaten they may be considered *garnishes*. Small quantities pickled or sweetened when used to contrast with other foods are called *relish*. When the leaf is cooked and eaten as a side dish, it is called *spinach*, but if it is mixed in stew

TABLE 5.—A comparison of the nutritive value of some edible green leaves and other classes of fruits and vegetables (per 100 g fresh weight)*

Vegetables	Calories	Protein in g	Vitamin A in IU	Vitamin B_1 in mg	Vitamin B_2 in mg	Niacin in mg	Vitamin C in mg
Leaves							
Cassava leaf	53	7	10,000	.14	.26	1.5	300
Tropical spinach	44	4	13,000	.15	.25	.85	100
Kankong	17	3	4,000	.15	.2	1.6	140
Green vegetables (av.)	22	2.4	5,000	.07	.15	.6	55
Yellow vegetables (av.)	18	1.5	500	.04	.06	.13	31
Pods and seeds							
Beans (pods)	33	2.2	200	.08	.10	.6	13
Asparagus bean (pods)	18	2	1,200	.10	.10	1.1	20
Peas (seeds)	48	3.4	1,500	.28	.12	2.0	10
Young fruits							
Cucumber	10	.6	200	.04	.05	.16	10
Okra or gombo	29	1.8	1,000	.1	.1	.7	25
Tomato	18	1	1,200	.05	.04	.7	25
Tubers							
Cassava (fresh)	131	.7	0	.02	.1	.6	30
Sweet potato (fresh)	121	1.5-2	0-5000	.1	.06	.7	20
Cocoyam (fresh)	88	1.5-2	40	.05	.06	.4	6
Fruits							
Banana	103	1	100-350	.05	.06	.5	10
Papaya	38	.6	2,500	.02	.02	.1	60
Orange	43	.8	250	.08	.03	.2	25
Mango	59	.7	1,000	.06	.05	.2	30
Watermelon	26	.5	500	.05	.07	.05	6
Avocado	210	2	200	.1	.15	.1	20

* Terra, 1966.

or with other vegetables, it is a *pot herb*. When the leaf imparts a desired flavor to the dish it is a *spice* or a *condiment*. However, when the cooked dish is taken as a beverage, it is a *tea*. Leaves may also be soaked in water to give an *infusion*, used as tea or for medicinal purposes. Some green leaves have many different uses.

Classification by Importance

Green leaves may be classified into those of commerce, those more suited to home gardens, and those that grow wild. The classification into commonly available, and exotic species also has practical value. Importance can be measured many ways, by economic value, by frequency of use, or by contribution to the diet. Each method of classification adds useful information to the description and understanding of the species.

Use of Green Leaves Throughout the Tropics

Whether or not green leaves are accepted as part of the diet is largely a matter of education and experience. These particular cultural and dietary phenomena are largely related to geography. For example, green leaves are an accepted part of the normal diet in tropical Africa. The knowledge of the various species is widespread and systematically passed on through the home. Cultivated and wild species, their seasons, uses, and tastes are well known. Many of the species are marketed or bartered, and are even carried long distances to sell.

The number of species used in Africa is large, perhaps 500. It is interesting to note that many of these are introduced species. Probably the people of Africa have experimented with the edible qualities of newly introduced plants, and there are probably few that have not been tested.

In Africa the green leaf is generally cooked into a stew that is eaten with a staple starchy food. The stew offers to the diet many of the nutritional qualities not available in the starchy staple.

In the Orient the situation is somewhat different. There heavy population pressures and frequent starvation have forced a systematic study of the edible qualities of all plants. The discoveries have often proved not only edible but also nutritious. A highly skilled and sophisticated treatment of new edible greens has developed with time into a unique form of cookery. Now green-leaved plants are eaten not only to fill the diet but also to add variety and to please the taste.

In Southeast Asia, including the area from India to the Philippines there is an enormous diversification of plant materials, which is almost matched by the diversification of languages and peoples. It is highly probable that an equally energetic process of exploration for edible leaves has occurred. Many trees, including those of the forest, are known for their edible leaves. A wide variety of other fruits and vegetables are used also as a source of leaves. The attitude appears to have been, "if it is green, try to eat it." Probably many of the uses of wild species have not yet been recorded. Unfortunately, while this area is rich in known edible leaves, ignorance and prejudice often result in unnecessary malnutrition.

On the other hand, green leaves are not now an important item of the diet of the peoples of Central and South America. In fact, the edible nature of the green leaves of many native and introduced plants is largely unknown except to the initiated few. At the present time it is uncertain whether this lack of interest in leaves is a recent development or whether it characterized equally the original peoples of the area. The records are not extensive enough to be sure, but the Indians of North America did eat leaves and did recognize edible and poisonous species. It can be presumed that many uses of green leaves have died out as a reaction to the views of those who depreciated local customs

In the treatments of wild and domesticated edible plants of tropical America few edible greens are mentioned. Most of those that have come to the attention of economic botanists are introduced plants. Nevertheless, a few special items merit attention as being Latin American in origin, including the leaves of *Arracacia xanthorrhiza* and *Pereskia bleo*, and an assortment of palm cabbages. The following sources of green leaves in South American are of particular nutritive value: *Amaranthus gangeticus* L., *Chenopodium berlandieri* Maq., *Malva parviflora* L., *Crotalaria longirostrata* Hook. & Arn., and *Cucurbita pepo* L.

Among the few uses of green leaves in South America, the use of the leaves of cassava was widespread. It was a logical practice closely related to the source of a principal stable, and must have had salutory effects on the diet. Nevertheless, the custom of eating such leaves is not universal. In Latin America today green leaves are frequently depreciated.

Sources of Information on Edible Leaves

In spite of their importance in the diet, little has been written on edible leaves of the tropics. The published information available is generally hidden in more general publications concerning tropical gardening or useful plants. This information is often quite repetitive and seldom complete. The best single source of information which can be recommended for the principal species is Ochse and Bakhuizen van den Brink, 1931 (See later). Seeds and plant materials are also difficult to find, although some species are offered in commercial seed catalogs. The present authors obtained and tested some of the leaves included here only with much difficulty, and others were not tested at all. In most cases, the serious student will not find any single source that gives more information than that presented here, but major review papers are mentioned in the text describing particular vegetables.

Some of the better general sources are given below. Full references are given as an appendix.

Vegetables of the Dutch East Indies (Ochse and Bakhuizen van den Brink, 1931). One of the richest sources of green leaved vegetables is Indonesia. As a crossroads of Southeast Asia practically all edible plants of the surrounding regions have been introduced and many have become part of the diet. This volume is one of the authoritarian works in this field. First published in 1891, it was only translated to English in 1931. Principally vegetables used as pot-herbs and side-dishes are covered, but tubers, bulbs, rhizomes, and spices are also mentioned. The problem of today is obtaining a

copy. For many years out of print, it is now a collectors' item, difficult to even borrow.

Tropical Crops, Dicotyledons (Purseglove, 1968). The text of this remarkable and useful publication is arranged by families. Most of the principal crop plants of the tropics are treated, but emphasis is definitely on plantation crops. Information on greens is usually quite brief, and except for a few principal species, cannot easily be located. Frequently the only mention of an edible green is a reference such as "used for pot herbs". Nevertheless, because of its high quality and extensive coverage of tropical plants, it is a reference of considerable value in the library.

Handbook of Tropical and Subtropical Horticulture (Mortensen and Bullard, 1964), is an extremely condensed treatment summarizing information taken from many other sources. Tropical greens are treated briefly, not nearly as adequately as they merit.

Fundamentos Botánicos de los Cultivos Tropicales (León, 1968). For the Spanish speaking person this book is a particularly valuable source of information on the edible green-leaved species of South and Central America. Only the principal species are dealt with. Most are illustrated by hand drawings. This book is very good for its regional flavor.

Tropical Vegetables, Vegetable Growing in the Tropics and Subtropics, Especially of Indigenous Vegetables (Terra, 1966) is particularly valuable as a comprehensive list of major and minor vegetables. As is the case when many items are included, the textual information is often quite brief. However, most of the principal species are well treated.

Vegetable Production in Southeast Asia (Knott and Deanon, 1967) is probably the best text on tropical vegetables, and is particularly useful for its chapters on principles of production. Many unusual vegetables are treated here, including some of the better edible greens.

The Samaka Guide (Samaka Service Center, 1962). An integrated approach to subsistence on a small (600-1000 meter) lot in the Philippines is presented in this publication. Native and introduced vegetables, including edible leaves are described, along with practical suggestions for use. The book is enriched by its folksy style, handdrawn illustrations and earthy suggestions. In addition to its value for gardening, it merits a place in the library for its unusual nature.

Useful Plants of the Philippines (Brown, 1951). These volumes, with their encyclopaedic tendency, rival those of Burkill as sources of information on plants from Southeast Asia. However, while a good source of general descriptions and an excellent source of information on medicinal uses, the food uses of green leaves are often overlooked. This is particularly true of important economic species used for other purposes, but of which the leaves can be eaten.

The Food Plants of the Philippines (Wester, 1921). Although relatively old and based in large part on two even older treatments, continues to serve as a useful source on information on native edible plants of the Philippines. Many of the 444 species described are not available from other areas. Their names, characteristics, edible parts, and methods of use are well presented. Cultural information is sometimes given, together with geographical distribution. Comments on the relative importance of the species are particularly useful.

List of Foods Used in Africa (Claude, 1967). Nearly 4000 items are included in this comprehensive, well-documented, paperback publication. Foods are classified into 20 groups, of which more than half are entirely of plant origin. Because of the large number of species listed the information is held at a minimum, and consists chiefly of names, areas where eaten, parts eaten, frequency of consumption, and references. More than 400 exact references are given. These include practically every relevant publication in English and French. They can often provide additional information on species of interest. Group 7 consists of vegetables. Over 1000 are listed, and of at least half of these the leaves are eaten. Especially useful is the frequency of consumption scale by which the relative importance of each leaf-bearing species can be judged. Unfortunately, the family to which the species belongs is not listed, nor is the method of preparation given. Occasional foot notes clarify some of these points. Many of the minor species that are listed in this volume have not been dealt with in the case of the present treatment.

Fruits and Vegetables in West Africa (Tindall, 1965). Considerable information is provided on a variety of native and introduced green leaf vegetables of West Africa. Details of cultivation are included. The treatment is fairly up to date and practical.

A Dictionary of the Economic Products of the Malay Peninsula (Burkill, 1935) is one of the best sources for information on any economic plant of the tropics. The encyclopedic tendency of this 2-volume work prevents detailed treatment of most species. A very large number of plants with edible leaves or shoots are mentioned, including those used for minor purposes, such as for condiments, relishes, etc. Plants are listed by their scientific names arranged alphabetically. An easy book to use, it is made much more valuable by marginal notes that quickly guide the reader to the information desired. The wide range of information given on local usages makes for entertaining reading.

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CHAPTER II

The Principal Edible Green Leaf Herbs of the Tropics

A quick glance at the appendix of this volume should suffice to show that the number of species bearing edible green leaves in the tropics is very large. Most of the listed species are not well known, not well distributed, and have a limited potential. Only a few of the green leaf sources have become world travelers, and it is only from these that sufficient information is available.

Among the characteristics of the better species included in this chapter are availability throughout the tropics, ease of cultivation, relatively long periods of production or relatively high amounts produced, and acceptable flavors. All of these are cultivated plants that normally grow better when systematically cared for. But most also occur wild at times, or survive well when abandoned.

The species mentioned in this chapter by themselves constitute a select group that should satisfy every taste.

Amaranthaceae

Amaranthus paniculatus L., *Amaranthus tricolor*, *Amaranthus cruentus* L. (Chinese spinach, edible amaranth, bush greens) are examples of the cultivated species of this genus, well known chiefly for their edible seeds in Mexico and Central America, but equally useful as pot herbs. The amaranths are of the few genera of plants domesticated in both old and new world tropics. The leaves of many wild species are equally edible. These species probably arose in close association with the cultivated species. Generally the wild species are considered to have hybridized frequently with the cultivated and to have produced in this fashion a series of intermediate types. However, some of the species are separated by rather strong reproductive barriers.

Amaranthus species are distributed throughout the temperate zone and the tropics. The best types for use as spinach or salads, however, are cultivated in southeastern Asia and West Africa. In the former area the number of varieties is very large. The use of the plant in such areas is widespread and greatly appreciated.

The species are all herbaceous, short-lived annuals (Fig. 2). They are upright and branch sparsely. The leaves are relatively small (5-10 centimeters in length) but quite variable among varieties. Some varieties are purplish with betalain. The flowers are small, and are borne in abundance in terminal or axillary spikes. The life span of these species is rather short.

The seeds are borne in large numbers, and though small are edible. The flowers are not edible. The leaves, their petioles, and the young tips are sometimes used in salads. This is a dubious practice as the oxalic acid content of some species is uncomfortably high (1-2%). Boiling produces a very acceptable spinach. From a nutritional standpoint, vitamins A and C, and calcium and iron are found in good quantity.

The amaranths are generally propagated from seeds. These germinate irregularly, a characteristic that facilitates the weedy nature of the genus.

Figure 2.—A broad-leafed variety of edible amaranth.

They are not exceptionally sensitive to season and thus may be planted any time. The young seedlings 5-8 cm high are transplanted 8-15 centimeters apart. Delayed transplanting reduces yields. Tender plants need some protection from hard rains. The soil should be very fertile, preferably with added manure, compost, or nitrogenous fertilizer. Plants grow very rapidly and thus require ample water. Some species can tolerate drought, but of course produce little edible material under such conditions. Leaves and tender shoots can be harvested at any time. It has been shown that yields are best when the upper portions are cut routinely at 2-3 week intervals. Eventually the plants begin to flower and develop less leaves. Frequent cutting delays the onset of flowering and thus prolongs the effective life of the plant. Close spacing (23 x 23 cm) stimulates height of plants and increases yield per unit area.

Amaranth leaves are particularly attractive to chewing insects. These may decimate a planting in a very short time. A useful practice is to cover the bed with a fine screen to eliminate insects. Insecticides are also used for this purpose, a risky and debatable practice when harvests are made so frequently.

Because of their high nitrogen requirement and attraction to insects, the edible amaranths are more difficult to grow than many other green-leaved vegetables. Nevertheless because of their succulent nature and excellent leaves, the amaranths can be considered one of the better sources of edible greens.

Celosia argentea L (Quail grass) is one of the many edible species of this widespread tropical genus. The cultivated cristate form of the former is widely grown in the temperate zone as the summer annual cockscomb. Although now widely scattered through the tropics, it is of Asiatic origin. It is often weedy. The edible species are most commonly used in Southeast Asia and West Africa. Some species (*C. trigonal* L.) have medicinal uses, and even the edible-leaved species are slightly diuretic.

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 even the green foliage may contain large amounts of betalain pigments.

The leaves, young stems, and young inflorescences are eaten as a pot herb. Much of the pigment is lost on cooking and the darkest, uglist cooking water is produced. Nevertheless, leaves retain a pleasant green color. They soften up readily and should not be overcooked. Texture is somewhat soft, and the flavor is very mild and spinach-like. Bitterness is entirely lacking.

The plants normally require somewhat rich conditions for maximum development. Nevertheless, some forms are weedy and produce even on dry bare land.

Aizoaceae

Tetragonia tetragonoides (Pallas) O. Ktze. (New Zealand spinach) is a vigorous, rapidly growing prostrate herb that appears to be widely adapted in both temperate and tropical climates. It is native to New Zealand but has been widely introduced and now is often found weedy, especially on beaches and in sandy areas. It has become an important spinach in many tropical areas

because it can be grown where temperatures are too high for temperate zone spinach (*Spinacia oleracea* L.). Nevertheless, it too has its temperature limits, and should be considered a subtropical or upland herb. In the Philippines it grows best at elevations of 600 meters or more.

The species is distinguished by its thick fleshy, spreading stems, its succulent, alternate, short-petioled leaves that are deltoid in shape, small, inconspicuous petalless flowers borne in leaf axils in small numbers, and a dry, hard, horned fruit. It is usually described as an annual, but occasionally persists as a perennial. Under appropriate conditions it can survive for many years and old plan can be repropagated from cuttings.

The young leaves and about 3 inches of stem are eaten, usually as a spinach dish. When other greens are not available the shoots serve well uncooked in salads, where they are especially noted for their crispness. This practice is not recommended because of the saponin content. New Zealand spinach is rich in iron, and a very good source of calcium and phosphorous.

Plantings can be established either from cuttings, which root very easily in damp sand, or from the large brownish fruits. The seeds germinate very irregularly. Soaking them in water for 24 hours is useful. Initially the seedlings are too succulent to transplant easily. A sandy soil is especially desirable in the case of this plant. On such a soil the plant will spread rapidly. The drier surface assures less rot of the prostrate stems. Nevertheless, good fertility, especially nitrogen fertilization, is desirable for an abundance of succulent growth. Because of the dense growth habit of this species, a few plants suffice for a family. Due to its drought resistance, and immunity to most insects, the planting needs very little care.

As it is an easy vegetable to grow, and nutritious as well, New Zealand spinach merits a corner in any tropical vegetable garden.

Araceae

Xanthosoma brasiliense (Deaf.) Engler (Tanier spinach, Tahitian Taro, Belembe) probably has its origin in the river valleys of Brazil, but was distributed throughout tropical South America, and was cultivated for its leaves in pre-Columbian times. Since then it has been taken to all parts of the tropics, and frequently has replaced *Colocasia* in usage of leaves. It is not well known, but is very much appreciated by those who do know it.

The plant develops from a rather insignificant corm which, unlike the corms of most *Xanthosomas*, never becomes very starchy. These corms offshoot readily so that a normal plant consists of a colony of small corms clustered around the mother corm. The species is a perennial capable of growth throughout the year. Under favorable conditions, it may reach a height of 80 cm, but more normally is about 50 cm tall. The leaves are sagitate to trilobed (see cover), glabrous, dark green, fairly smooth, and succulent (see cover). They are produced singly in rapid flushes of growth. The petioles are long and succulent. No above ground stem is produced.

Leaves and stems are eaten. Some people prefer the very tender young leaves, but once one is accustomed to the stronger flavor of older leaves, they are then preferred. Only aging and diseased leaves need be rejected. The upper portion of the petioles is also sufficiently tender to be eaten, but the very

lowest parts are tough without excessive cooking. Corms are edible, but because they are small and not very starchy, they are seldom used as foods.

The leaves may be harvested for food at any time. For commercial purposes whole, mature leaves and petioles are cut from the plant and bundled together. For home use frequently all leaves are cut, and then sorted in the kitchen to eliminate unsuitable leaves or portions of leaves. The leaves wilt promptly if not protected by water sprays or by plastic bags. They may be stored several days in a household refrigerator before use.

Although the leaves are said to be used in salads, the authors find that the calcium oxylate crystals are usually too irritating for use raw. Before cooking the leaves and stems are cut to appropriate size. They are boiled 10-15 minutes, until the stems are soft. Overboiling results in a pasty dish, and should be avoided. The softened preparation is served as a spinach with salt, light seasoning or butter. Because its flavor is excellent it is generally preferred as a spinach over all other greens.

From a nutritional standpoint, this spinach is worthwhile particularly for its calcium, phosphorous, vitamin C and vitamin A content. The protein content is only 3 percent.

Propagation is by replanting the offshoot corms. The center corm is sometimes large enough to be cut into 2 or 3 pieces for propagation. Any season of the year is suitable for planting, but other requirements must be met. The soil requirements are rather exacting. A loam or clay soil is quite suitable, but sandy soils are not tolerated. The soil must be retained at a high level of fertility. Organic material in the soil is particularly useful. Nitrogen requirements are high. Furthermore, the plants require large amounts of water and even tolerate occasional flooding. During dry conditions the older leaves die back rapidly. The plants grow best in full sunlight or very light shade.

Suitable leaves for harvesting are produced in 2-3 weeks, but about 6 weeks are required to bring leaves to a mature state. Harvests of single leaves can be made each week, or of all the leaves every 6-8 weeks. Refertilization should be frequent. Plantings lose vigor with time, and transplanting is thus desirable every 1 or 2 years.

Few pests or diseases are found. Vigorously growing plants often develop symptoms of virus. Because of vegetative propagation virus diseases have probably accumulated, but these are tolerated. Occasionally root and tuber rots occur but these, too, seldom cause serious concern. Leaf spots are common, but generally principally affect the older leaves. Precautions against diseases are generally not necessary, but production on a commercial scale would undoubtedly reveal new problems.

Xanthosoma spp. (Tanier, tania, yautía, cocoyam) are plants closely related to the taros and dasheens, but without peltate leaves (Fig. 3). The various species are difficult to classify, especially from vegetative characteristics and indeed may be closely related. The taniers are of New World origin. They were cultivated and widely distributed in pre-Columbian times. By now taniers have been introduced to all parts of the tropics, but are particularly well known in Africa.

Superficially, plants of the genus *Xanthosoma* are quite similar to plants of *Colocasia*. In addition to the difference mentioned above the plants

Figure 3.—Leaves of *Xanthosoma* (left) and *Colocasia* (right).

produce fewer leaves but these are often larger, with a much stouter petiole. They are usually arrowhead-shaped. A few species produce above ground stems. The typical spiked and sheathed flowers are rarely seen.

The principal corm is large, spherical to ovate, and usually quite acrid. The lateral corms are borne in abundance from the base of the principal corm.

Xanthosoma species are grown chiefly for their starchy corms. The starch grain is large and not easily digested. However, the leaves make excellent greens if carefully prepared. This means using chiefly the younger leaves, and peeling the petioles. Oxalic acid and calcium oxylate occur in abundance in leaves, stems, and some corms. The use of baking soda to neutralize the oxalic acid is recommended. Leaves are frequently stewed in native dishes. The unfolded leaf is preferred.

Tanniers are propagated from the large central corm. This can be cut into several pieces, preserving at least one eye in each. The soil should be rich and deep. Heavy clays are well tolerated. Much water is required through the relatively long season of growth (8-11 months). Some mechanical aid in harvesting of the tubers is desirable. The leaves, however, may be harvested at any season. Plantings are relatively free of pests and diseases.

Among 22 varieties of tanniers tested, differences were encountered in the cooking time necessary to reach tenderness, in the color of the cooking water, in the appearance and attractiveness of the cooked leaf, and in flavor. The calcium oxylate cristals persisted more in some than in other varieties. The range in quality led us to rate varieties from inacceptable to excellent. The Puerto Rican varieties judged excellent were Dominicana and Inglesa.

Because of the availability of the superior species, *X. brasiliense*, the taniers cannot be recommended as a leaf vegetable for the home garden. Where the species are grown for their corms, the leaves may be used, however, as a by-product.

Colocasia esculenta (L.) Schott consists of two well-defined varieties. That with elongated corm is called taro and is generally grown by paddy culture. However, upland (non-paddy varieties) are also common. The botanical form *globulifera* (dasheen, malanga) is set apart by various characteristics. Cultural techniques are generally upland. Taros and dasheens were well distributed from the islands of the Pacific to Egypt in pre-Columbian times, and of course, are now widely grown throughout the tropics, as staple crops.

The taros and dasheens both form large corms from which the leaf petioles spring. There is no above-ground stem. The leaves are large, mostly peltate, and rather succulent. They are short-lived. New corms form readily at the base of the old.

Taros and dasheens are grown principally for their edible, starchy corms. The corm of the taro is of a spongy texture and contains much fiber. It is difficult to cut. Taros are therefore often beaten after cooking to free the starch materials and to make the partially fermented dish, poi. The corm of dasheens, on the other hand, is much more crisp, cuts easily, and is more often used just as a boiled vegetable. There are many varieties each of which differ in details and are well known for their particular virtues.

All taros and dasheens contain quantities of oxalic acid crystals. When the leaves and petioles are not too acrid, they are frequently eaten. Among

74 taros of the Pacific described by Whitner, *et al.* (1939), 5 varieties are grown principally for their leaves and 7 belong to a non-acrid group of which the leaves are often eaten.

Either the blade or the petiole may be eaten. The commonest methods are to eat them as a side dish (sometimes pickled), in a stew; or as a green wrap for baked foods. The leaves and petioles of dasheen are generally more acrid, and are cooked with baking soda or fat meat to counteract the oxalic acid. On preparation of petioles the skin is often removed. This is not necessary if the leaves are small. The unfurled leaves are eaten before the crop is harvested, and are especially delicious.

A further use for taros and dasheens is as a blanched shoot vegetable. The corms are placed in the dark where they eventually sprout. The blanched shoots make one of the most tender of vegetables.

In the West Indies a stew, calalou, is often made from the leaves of dasheen. The recipe f... this delightful dish is given below; in one of its early forms:

Ingredients	Quantity
Young dasheen leaves	Enough for four persons
Okra	Ten or twelve pods
Bananas (almost green)	One (cut in bits)
Roselle (Sorrel)	Handful
Ham (or other meat with fat)	One pound
Peppers	One or two small bird peppers
Rosemary	A very little (to taste)
Cloves	A very little (to taste)
Nutmeg	A very little (to taste)
Cinnamon	A very little (to taste)

Take as many young dasheen leaves as will make the amount of plainly prepared dasheen desired. Wash the leaves and take out the midrib and largest veins. Have ...ly enough boiling water as is absolutely necessary. Put in the meat chosen and the dasheen leaves. After half an hour, add all the other ingredients, with spices to taste and sufficient peppers to make the dish quite hot. Cook until all the ingredients except the salt meat are quite soft, then take out the meat. Stir well with a swizzle stick or egg beater. Guard against burning by having a slow fire or an asbestos mat under the casserole. Time of cooking, about two and a half hours.

In the place of the ham mentioned, the following may be substituted, the total quantity of the substitute always being one pound. Salt pork, 1 lb., or crab meat, 3/4 lb. and 1/4 lb. salt pork, or frog legs, 3/4 lb. and 1/4 lb. salt pork. Any of the above ingredients may be omitted *except* the *dasheen*, the bananas, one meat and fat, the peppers, and the roselle. If roselle is not procurable, the juice of a lime may be substituted.

Dasheen makes the principal constituent of the dish which when ready, resembles a puréé of spinach in color and consistency. It is eaten with hot boiled rice, the rice having the calalou served over it (as a bread sauce over fowl, or a curry over rice is served) in the proportions of half rice and half calalou.

The starch grains of taro and dasheens are very small making the starch very digestible. As a baby food, particularly in the form of poi, taro is said to

be non-allergenic. The protein content is fairly high in some varieties but is low in sulfur-bearing amino acids, methionine, and cystine. On the other hand, the food value of the leaves is generally considered high.

Paddy type taros are normally grown in submerged beds where a steady flow of water is maintained. Fertilizers or rotted plant materials are incorporated in the soil. The plants are propagated either from the small side shoots or from the upper portion of the corm of the principal shoot. The propagules are planted in the mud 12-18 inches apart. As the new leaves form the paddy is gradually flooded. Periodically the beds are drained for weed control and for fertilizing. Harvest takes place from 11 to 15 months after planting by pulling or prying out the corms. They are trimmed on top and bottom, washed, and marketed. The leaves, on the other hand, may be harvested at any time during the long growing season. Light harvesting of leaves does not materially affect the yield of tubers.

The culture of upland taros and dasheens is quite similar. The same types of propagating materials are used. The soil should be exceptionally rich and almost continuously well-watered. These plants tolerate poor drainage but cannot stand very much dry weather. Harvesting is done after 11 months. Some mechanical assist, such as a moldboard plow is desirable to remove the tubers. As with taros, leaves and petioles may be harvested at any season.

Basellaceae

Basella rubra L. (Ceylon spinach, Malabar nightshade, Libato), is a very succulent trailing or climbing perennial vine that apparently originated in India or Indonesia, but which has now spread throughout the tropical world, and is even used in the temperate zone as an annual. It is one of the better of the tropical spinachs, and is widely adapted to a variety of soils and climates. A short review of this species and its characteristics has been presented by Winters (1963). Ceylon spinach is particularly abundant and appreciated in India, Malaysia, and the Philippine Islands but it is also seen throughout tropical Africa, the Caribbean and tropical South America.

The little known family Basellaceae, consisting of only 4 genera, shares many of the characteristics of the Chenopodiaceae. *Basella* consists of only one species, but two specific names are often applied. The foliage of *B. rubra* is deeply colored red like the foliage of the table beet. Its green form is sometimes distinguished by the name *B. alba*. On germination of the seed, the cotyledons are large, fleshy, and continue to grow for some weeks. The foliage and thick tender stems are glabrous. The leaves are almost circular to ovate, alternate, and short petioled (Fig. 4). 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. The juice is sometimes used as a dye.

The succulent young and mature leaves, and the stems are eaten. Inflorescences, unless very young, are tough and should be avoided. The most common method of cooking is as a pot herb, mixed with stew or other vegetables. However, the young plants also make excellent cooked greens. On cooking, the green form retains its fresh green color. The red form loses much pigment to the water, and is less attractive. The odor of the cooked leaves is

Figure 4.—Young plant of *Basella rubra*, Ceylon spinach.

strong. The leaves themselves have a mild flavor or are almost tasteless. The stems may be somewhat bitter, but not objectionably so. The stems in particular become somewhat gelatinous or mucilagenous, especially if overcooked. The green leaves can also be used uncooked in salads as an acceptable lettuce substitute. From a nutritional standpoint, Ceylon spinach is a good source of vitamin A and C, calcium, and iron. Protein content is low as compared to that of other leaves.

Ceylon spinach is a perennial that tends to extend itself with time. When it runs over a light enough soil, it can develop new roots at the nodes, and thus continue indefinitely. If given supports on which to climb, it can develop a superstructure, but it is not a strong climber. After 2 or more years, individual plants, if not well cared for, tend to die back. Nevertheless, with fertilization, hedges may be maintained of this species for long periods, and production is continuous.

Although *Basella* is tolerant of many soils, a sandy loam appears to be most suitable. In such soils the seeds can be sown directly. They germinate within a few days. Or, the vines may be established directly from stem cuttings. These need a little shade on transplanting, but root readily. Plants are spaced at about 3 feet. *Basella* can thrive under conditions of only moderate fertility, but is quite responsive to added nitrogen.

The first harvest can be taken as little as 4 weeks after planting, but this stunts the plants. After about 3 months, the established planting may be pruned every week or so to produce an edible crop. The leaves and about 3-5 inches of stem are harvested. *Basella* vines branch readily, and frequent harvest is desirable to maintain the planting within bounds. During the season of most intense flowering (short days of winter) the leaves tend to be small, and the new growth occurs chiefly as new flowering clusters. Excess pruning may help at this stage to maintain the production of new green shoots.

Plantings remain remarkably free of insects and disease problems, and need little attention besides adequate watering and harvest.

Convolvulaceae

The sweet potato, *Ipomoea batatas* L., originated in the New World, although the site of origin and the manner in which it originated are still unknown. Distributed as far as New Guinea and New Zealand before the time of Colombus, the sweet potato was an important crop related to the colonization and welfare of the islands of the Pacific. Its range has since been extended so that the species is known throughout both temperate zones and tropics. Propagated vegetatively, the sweet potato is represented by thousands of varieties, but is seldom seen in the wild state.

Sweet potato is normally a trailing vine, although climbing forms resembling typical morning glories are known. Although a perennial, its succulent nature restricts its cultivation to relatively short growing seasons of 3 to 5 months. Unlike many roots and tubers it begins to store starch at a very early stage, making early harvests possible. It is one of the most efficient plants to capture the energies of the sun as calories.

The production of starch in root tissue is the principle reason for planting the sweet potato. However, the edible leaves and stem tips are well

known. Often considered a poor man's food, sweet potato foliage has a rich protein content that helps fill the nutritional gap left by eating principally the protein-poor tubers. In West Africa sweet potato greens are particularly important, and varieties have been developed that are used only for the leaves. These are especially rich in calcium.

In a study in the laboratory of their cooking qualities, 44 varieties of sweet potato were found to differ in their general appearance, in flavor and amount of bitterness. Many varieties have a resinous flavor that is not objectionable unless quite strong. Because of anthocyanin content and other phenolics, the cooking water is often unpleasantly colored. It should always be discarded.

Raw leaves are said to contain some HCN, and therefore thorough cooking is desirable. Accounts of vomiting and purging associated with eating the young tops might be related to the presence of poisonous substances commonly found in other species (*I. purga* Hayne), which are sometimes used medicinally.

Because it is so easy to culture, and because the species yields edible roots as well as leaves, sweet potato merits a place in the tropical garden. Leaves and tubers can be produced year around, and plants resist climatic extremes. Most soils are suitable, but richness of organic material or nitrogen promotes lush growth of leaves.

Ipomoea aquatica Forsk., or *Ipomoea reptans* Poir (Kangkong, Water spinach) is an important green leaf vegetable crop in Taiwan, Malaysia, Indonesia, and Southeastern Asia, and it is a plant that must have been domesticated centures ago, probably in China, which has been introduced sporadically throughout the tropics and semitropics, but has not become popular elsewhere. Wild forms have become established in many areas of the tropics, where they are occasionally put to use. An account of water spinach, its cultivation and importance, has been given by Edie and Ho (1969). Several varieties are known, but the most important distinction is between upland (dry) forms and paddy (swamp) forms.

The species is a trailing vine that spreads rapidly by rooting at the nodes. Vertical branches arise from the leaf axils. It is quite glabrous, with sagitate, alternate leaves. The foliage is somewhat succulent, particularly so in the case of the wet land form, and has a pleasant light green color. A white flower is produced, followed by a 4-seeded pod.

Practically all parts of the young plant are eaten (Fig. 5). Older stems, especially of plants cultivated on dry land, contain considerable fiber. Cultural methods emphasize the production of young, succulent tips. These can be eaten fresh in salads. The flavor is agreeable. More frequently, they are cooked as a spinach. Cooking in oil is also very common. The flavor is bland, and something should be added to enhance it. The leaves maintain much of their green color, but the yellowish stems are not attractive.

The protein content of the leaves is high making this species one of the best green-leaved foods. In addition, it is a good source of vitamin A, iron, calcium, and phosphorus.

In South China where the culture of water spinach is most advanced, two types of culture are common. Particular varieties are adapted to each set of cultural conditions. In the tropics some modifications of the Chinese techniques are desirable.

Figure 5.—*Ipomoea aquatica*, Kangkong, at the proper stage for use as a pot herb.

Varieties are planted either from seed or from cuttings. Seeds do not germinate well under water, but nevertheless can be direct seeded. Plants are frequently grown in nursery beds for later transplanting. Cuttings can be overwintered, but are generally taken from nursery beds. They are rooted directly in mud in the case of the paddy method.

In both upland and paddy culture large quantities of organic material are almost continuously added to the soil. This results in lush growth and very high yields (in the case of paddy culture, 45 metric tons per hectare). For upland culture the plants are spaced at 12 cm in raised beds. They require large amounts of water. Weeds are inevitably a problem. The entire plants can be harvested 60 days after planting or the vines are allowed to grow and may be trained to trellises. The latter technique permits a continuous harvest of leaves during the growing season, and is recommended for the home garden. In such cases harvest can begin 6 weeks after planting and can be continued at weekly intervals.

In paddy culture, long cuttings (30 cm)are planted in mud and kept moist. As the vines grow, the paddies are flooded to a depth of 15-20 centimeters, and a slow flow of water through the field is maintained. The water flow is stopped for purposes of fertilization. Weeds are well controlled by the flooded conditions of the field. Harvest begins after 30 days. When the succulent tips of the vines are removed, lateral and upright branches are encouraged. These are harvested each 7-10 days.

Plants switch to the flowering stage as the short days of winter approach. During flowering less vegetative material is available for harvest, but heavy pruning and fertilization will counteract this tendency.

Under tropical conditions water spinach may be grown on a year-round basis. The plants are perennial, and can continue several years. However, they tend to exhaust the fertility of their surroundings, and accumulate disease and insect problems. Because of the simplicity of propagation techniques it is probably desirable to begin again from seeds once each year, and to plant in new areas.

Cruciferae

Nasturtium officinale R. Br. (Watercress) is a European plant naturalized in the temperate zone of both hemispheres. It has been widely distributed within the tropics, where it often occurs as an aquatic weed. It is not extensively cultivated, except in an informal way, but excellent, long-standing plantings can be seen in Hawaii.

Watercress is a perennial herb that lives for years, even in temperate climates. The angular, hollow, much branched stems root freely at nodes below the water. The leaves are pinnately compound; leaflets are odd in number, and circular in outline. The frequent flowers are small, white, and inconspicuous. The pods are small, cylindrical narrow, and curved.

The plant may be propagated from seeds. The seeds germinate rapidly if adequate soil moisture is maintained. However, watercress is more frequently cultivated by cuttings that, even when soft and succulent, root readily in sand or a container of water. It can be grown conveniently in streams or ditch where it spreads profusely, and yields very well. It favors humid soil,

rich in organic material. Plants can also be grown on the soil surface, but watercress does not tolerate drying out. A familiar cultural system is to grow the plants in paddies such as those used for taro. Normally, a minimum of water is used, but when necessary to control pests, the beds may be flooded. Typical yields of watercress are so excellent that the species outranks most other edible crops in the production per unit area of calories, protein and other nutrients. It is high in vitamins A and C, and has a fair amount of vitamin D. Watercress is eaten raw in salads where it imparts a peppery flavor, or can be served as a cooked vegetable. In stews it is also a condiment. It is particularly good cooked with meat, and is a Chinese favorite.

Precautions should be taken to insure that the water from which the cress is taken is not polutted. If a doubt does exist, the greens should be cooked or thoroughly cleaned with an antiseptic solution. Washing alone will not make the plant safe for eating.

An almost sterile hybrid of *N. officinale* and *N. microphyllum* is also grown as a salad vegetable. Other species of *Nasturtium* also bear edible shoots and leaves.

Cucurbitaceae

Telfaria occidentalis Hook. f. (fluted gourd) is seldom seen outside of its habitat, tropical Africa. Nevertheless it is well-known, appreciated, and a frequent item of commerce there. The closely related *T. pedata* Hook. is also seen. It has a smaller fruit with less pronounced ribs. Both species bear edible seeds, but the former is grown chiefly for its edible leaves. Because of its tolerance to many soils and its highly productive nature, it merits wider trial.

Fluted gourd is a perennial vine, climbing to heights by tendrils. It is glabrous or almost so and tinted purplish by anthocyanin. The leaves are palmately divided into 5 or more segments (Fig. 6). The large fruits are characterized by thick, protuding ribs that give the wall added strength and durability. The seeds are large, up to 5 centimeters in diameter, and slightly flattened. The pulp is yellow to orange and relatively scant.

Fluted gourd can best be grown from seeds. These are often found to have germinated inside of the fruit. When planted in the garden such tender seedlings need a few days of shade and adequate watering. New vigorous plants are established readily. Stem cuttings can also be used for propagation. The vines are vigorous and climb rapidly. Therefore, they should be trained to a trellis that is not too high, but that permits easy access for harvest of vine tips. A variety of soils are tolerated, including those of low fertility, but the plant responds well to nitrogen fertilization. It resists drought.

Flowering begins the first year. Female flowers are not abundant. The fruits set readily and fruits grow to a size of 50 kg. in some cases. If the vines are grown principally for greens, it is wise to eliminate the fruits for they reduce the capacity for vegetative growth. The seeds of the fruit are generally utilized somewhat before the fruit is fully ripe. They are very high in oil content and can be rendered to supply cooking oil. On roasting, the chestnut-sized seeds are said to resemble almonds in flavor.

Vine tips are harvested in lengths of about 50 cm and are bundled together for marketing. Although these can be taken any time of the year, they

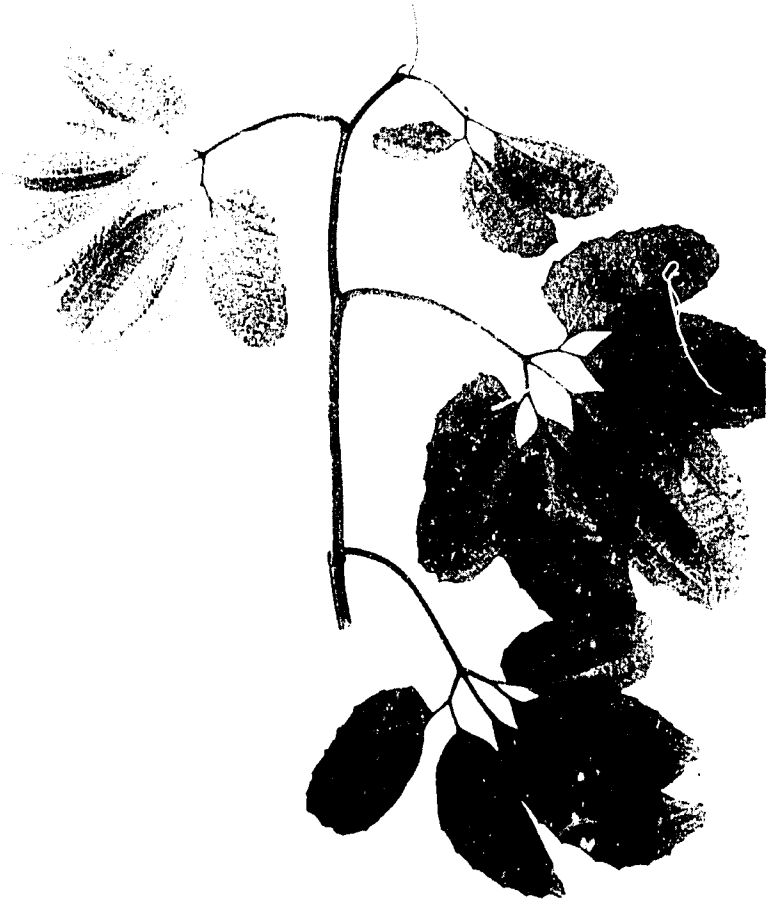

Figure 6.—The leaves of *Telfaria occidentalis* at about the stage they are marketed in West Africa.

are most abundant in rainy seasons. Before using, the leaves and tender tips are removed from the tougher stem. The tendrils are usually too fibrous to eat. The usual method of cooking in Africa is in a stew but the leaves make a very good cooked side dish. They retain their dark green color on boiling.

Euphorbiaceae

Manihot esculenta Crantz (cassava, manioc, yuca, mandioca) is best known for its starchy edible roots, used as a staple food in many parts of the tropics, and as a source of tapioca, starch, and animal feed in the temperate zone. Although it has its origin in the tropics of Central and South America, cassava is now so well known in both tropical Africa and Asia that it is often locally thought of as indigenous. Not everyone who appreciates the tuberous roots, however, is acquainted with the edibility of the leaves.

Cassava is a large (up to 5 meters) and ungainly woody shrub of relatively short life-span. It tends to branch irregularly and bears its large (20 cm long) lobed leaves near the tips of long branches. The leaves are short-lived (1-3 months) and are readily lost during drought or after insect attack. Inconspicuous, usually unisexual flowers are borne chiefly during the time of shortest days, and when pollinated give rise to trilobed capsules which burst on ripening. Leaves for consumption can be produced throughout the year if plants receive sufficient water to maintain their vegetative growth.

The portion eaten is generally the maturing leaves that are just reaching full size (Fig. 7). Although the younger leaves and a small portion of the stem may be consumed, it is advantageous to leave the growing point for further leaf production. Old leaves may be too tough and fibrous for consumption. Petioles, particularly when large, should be discarded.

Cassava leaves are not eaten raw, and indeed it is risky to do so. The leaves of all species contain harmful glucosides which easily release deadly hydrocyanic acid. Even leaves of sweet varieties that bear roots of low hydrogen cyanide content must be considered dangerous. To dispel the poison the leaves are boiled at least 15 minutes. The leaves are generally cooked into a stew in Africa, and this then is eaten with the cooked starchy roots. However, the leaves can be cooked alone as a side dish or spinach. The many different ways cassava leaves are used in Africa are presented by Terra (1964).

The nutritive value of the cassava root is chiefly its caloric content. On a dry weight basis the protein is normally only one or two percent, and is particularly deficient in essential amino acids.

In contrast to the starchy roots, the leaves of cassava contain sufficient protein to merit consideration in the diet. Values of 17.8 to 34.5 percent (on a dry weight basis) were reported by Rogers and Milner (1963). Protein content is higher in young leaves. The amino acid content is unbalanced, especially in the case of methionine. This essential amino acid is present only at a level of 60-80 percent of that desired. Levels of tryptophan are only marginal. On the other hand, the level of lysine is quite high in comparison to that of other plant proteins. Cassava leaves also contain appreciable quantities of B vitamins, phosphorous, and iron.

It is possible that large quantities of leaves in the diet might cause health problems. During cooking the enzymes releasing hydrocyanic acid

Figure 7.—Recently matured leaves of *Manihot esculenta*, cassava, at the stage for cooking.

from its glucosides are inactivated, and the resulting product is usually considered non-toxic. Some evidence suggests, however, that the glucosides themselves are poisonous, and that conditions such as goiter may result from long term habitual consumption.

Cassava plants can be grown as a hedge for the yard or garden. Some varieties are upright whereas others are bushy. The bushy habit can be promoted by harvesting shoot tips as well as leaves for food. Close planting heavy fertilization, and monthly harvesting of shoots should provide year round leaf production.

Methods of cultivating cassava are well known. Woody cuttings of about 12 inches are planted in the soil oriented upright, or with a slant, or are buried in shallow trenches. Such cuttings root readily and establish plants within 2 months. Growth requirements are not exacting. Almost any soil is tolerated, and in fact, cassava is frequently planted on the poorest of soils. Cassava also withstands drought, dropping its leaves, but recuperating after rainfall. Nevertheless, for purposes of leaf production, the plants benefit from high nitrogen in the soil and from adequate rain or irrigation.

Cassava is rather resistant to insects, but two particular problems may cause loss. During the dry season populations of red spider mites often develop and can defoliate the plants. These almost disappear when seasonal rains begin. They may also be controlled with miticides. Several species of flies often kill the tender growing point of the stem, causing proliferation of new branches. Systemic insecticides are very effective in ridding a planting of these flies, but their possibly harmful residues have not yet been fully studied. In Africa a principal disease is mosaic, which can be avoided by the use of resistant varieties. A troublesome leaf spot is known, which may make the production of edible leaves difficult. If precautions are taken, cassava can be considered one of the best of the tropical green leaf vegetables as it is one of the easiest to grow, most prolific and most nutritious. In addition, the roots are equally useful.

Sauropus androgynus Merr (Katuk). This is a common cultivated shrub, rarely wild, found from India to Malaysia. It is little known outside of its native areas, but merits wider attention as one of the most prolific, nutritious, and appetizing of the green-leaved vegetables. In trials in Sarawak this species has outyielded all other sources of green leaves. Its vigor, long life, year round production, and ability to recuperate after planting recommend it as a source of edible greens.

The plant is an awkward appearing shrub with long, upright main stems that tend to fall over with time due to their own weight. There is little tendency to branch. Pruning generally results in rapid production of one or more new upright shoots to replace that lost. Lateral branches appear to be compound leaves, but bear flowers along their undersides. The fruits, about one cm. in diameter, open and let drop their seeds at maturity (Fig. 8).

The tender tips, the young leaves, flowers, and the small fruits are used for food. These represent a very small portion of the entire plant. Older leaves can be stripped from the stems for cooking. The young leaves and tips, eaten raw in salads, have a strong, characteristic odor. They are more frequently cooked and have a distinctive, agreeable flavor. The leaves and stems tend to retain their dark green color and a firm texture. Roots and leaves are some-

Figure 8.—Leaves, flowers, and fruit of *Sauropus androgynus*.

times used medicinally. The plant is sometimes used to color preserves. The protein content of the leaves is good, from about 6 to 10 percent. It has been reported that excess consumption of leaves causes pain of the limbs.

Sauropus can be propagated from seeds, which are borne in abundance and germinate readily. Under conditions of adequate fertility, seedlings grow very rapidly. Or, cuttings root well if placed in appropriate conditions. Somewhat woody cuttings from 20 to 30 cm. in length are used. Plants can tolerate very heavy soils and heavy rainfall, but grow much better if attention is paid to good fertility and drainage. Because of their perennial nature, fertilizer in the form of mulch is preferred. The most usual and convenient way to grow katuk is as a hedge. Plants are established at intervals of 10 centimeters or more, and rapidly develop a strong hedge of edible leaf materials. The plants grow very straight without branching and need frequent pruning to maintain them at hedge height. The plant is frequently referred to as a low shrub. This is probably because it is maintained low, but its natural tendencies are to grow very high indeed.

Diseases and insects are seldom a problem. No special treatments are necessary.

Malvaceae

Hibiscus species are native to the Old and the New World, and are widely scattered by the action of man. The young leaves and even mature leaves particularly of the African, but also of the Australian species are often used for food. For purposes of this presentation only the most important food bearing species are mentioned, but others are included in the appendix. These are *H. sabdariffa* L. (Roselle, Rosella). *H. acetosella* Welw. ex Fic. (False roselle), and *H. cannabinus* L. (Kenaf). They are plants of African origin possibly domesticated in the Sudan but well distributed throughout tropical Africa. The first two species serve as a commercial source of fibers. Roselle, however, is better known as a vegetable of high quality. The forms used for fibers are distinct from those used as food, but all are edible. Roselle has been adequately treated in a review with kenaf and other *Hibiscus* species by Wilson and Menzel (1964).

A description of these species is difficult for each consists of numerous disparate varieties. The principal food producing form of roselle is a woody annual herb that is much branched, with glabrous or almost glabrous foliage. The fibrous forms are more erect. The leaves are green, and vary from entire to palmately divided. The stems are deep red. The attractive flowers, yellow with red center, are borne solitarily in the axils of the leaves, and the red, acidic calyx of these becomes enlarged and succulent. Plants of *H. acetosella* are very similar to some of those of roselle. It occurs in two main forms, one with bronze-green leaves and yellow flowers, and the other with entirely red foliage and usually pink flowers. The calyx is small, not fleshy, and not eaten. These species have the advantage over kenaf of resisting nematodes.

Kenaf, on the other hand, is a very woody, green-leaved shrub that grows to heights with little or no branching. It is chiefly used as a fiber source and has been extensively bred for that purpose. It is highly susceptible to root-knot nematodes.

Most varieties of roselle and kenaf are very susceptible to the length of day (photoperiod) although the latter is probably more sensitive than the former. Plants of even 15 centimeters can be induced to bloom by daylengths of 9, 10, or 11 hours. The sensitivity of particular varieties varies. Roselle is often used as a laboratory example of photoperiodic effects because of this sensitivity. Thus, time of planting exercises a profound effect on morphology of the plant.

Practically all parts of roselle are edible. The species is appreciated for the fleshy bases of the buds. These, when cooked, form a colorful sauce not unlike that from cranberries. The colorant is widely used in the preparation of jams, jellies, and other products. The seeds are eaten toasted, and in fact, the plant may have been domesticated for its edible seeds. The leaves and the tender shoots are sometimes eaten raw in salads, but are usually cooked, becoming somewhat mucilaginous, and reminiscent in texture and taste of rhubarb. The acid flavor is seldom excessive, and is easy to learn to enjoy. It is distinctive and lingering.

The leaves of *H. acetosella* are used in much the same way as those of roselle but they tend to be more sour. Upon cooking much of the anthocyanin coloring is lost, and the cooked dish may not be attractive.

Leaves and shoots of glabrous forms of kenaf are equally edible, are cooked as spinach in Africa and India. Removing the shoot of kenaf changes the growth habit, however, and makes the plant less useful for fiber. In Africa, where these species are so appreciated, the leaves of another vegetable, okra (*Hibiscus esculentus* L) are eaten in the same fashion.

All the edible *Hibiscus* species are propagated by seeds, which are produced in abundance. These can be sown directly if the soil is properly prepared. Because of the long tap roots of roselle, a particularly deep, loose soil is desirable. *Hibiscus* species are fairly tolerant of distinctive soil types but require good drainage and benefit from mulching and fertilization. The nematode-susceptible varieties grow poorly and produce little in infested sandy soils.

Plants grown for fiber are seeded in ridges at very close spacing. Individual plants of roselle may grow to a very large size, and thus need spacing distances of a meter or more. Roselle plants grow slowly in contrast to those of kenaf. To obtain maximum size, they are therefore seeded early in the rainy season when daylengths are increasing.

Because of their color and normal tendency to branch, false roselle plants may be grown as a colorful, temporary hedge. Pruning the hedge to shape and harvesting the leaves are one and the same operation. Under such conditions the amount of edible material produced in a small space is quite large.

The useful life-span of the plants of both roselle and kenaf is brought to a close by flowering during short days. Seeds are borne in abundance.

Because of its many uses, roselle merits its place in the home garden, and can contribute to a variety of dishes.

Portulaceae

Talinum triangulare (Jacq.) Willd. (Surinam spinach, water leaf) is a slightly succulent unobtrusive herb that has been introduced from South

America but has been accepted and cultivated widely throughout the tropics.

The plant is a small upright herb (Fig. 9) that branches readily, with obovate, spatula-shaped, glabrous leaves, and a minimum of petiole. Small, white-petalled flowers are borne abundantly.

The leaves and tender stems of *Talinum* are used chopped as salad. They have a slightly sour taste and a bitter, lingering after-taste. Their relatively high content of oxalic acid (1-2 percent) suggest that they should not be eaten in excess. On cooking the inner basal portion of the leaves may turn brown. This is not attractive, but is not harmful. The cooking water is tinted pinkish by pigments extracted from the leaves. The cooked leaves and stems are excessively soft and mucilaginous, and thus overcooking should be avoided. The flavor is mild but characteristic, and bitterness is absent. Older stems may have some fibers, but these constitute a very small part of the plant.

Talinum may be propagated from its abundant, small seeds which germinate readily. In fact, the plant reseeds itself in the garden, and may become weedy. The species is also propagated from cuttings. The more woody stems are preferred. Most of the leaves are removed and the cuttings of 10-15 cm. are planted 5 cm. apart in rows. If protected from drying, the cuttings root in less than 2 weeks, and shortly thereafter produce new edible growth. Soil requirements are not stringent, but fertility of the soil leads to a more rapid and succulent production. Adequate moisture is essential.

Harvest can be made at any time and in fact the young weedy plants can be used as a vegetable. It is better to let the plants reach about 30 cm. and then to cut the branches back to the main trunk. Well-pruned plants have a life expectancy of a year or more, and can produce regular crops at least each two weeks.

The genus *Talinum* consists of 50 species or more, some of which are used as food in Africa. Others are occasionally grown as ornamentals.

Tiliaceae

Corchorus olitorius L. (Jews mallow, bush okra) is probably the most important source of edible green leaves in a genus known for such species. Authors differ in opinion as to the origin of the species. It is most likely from Africa but was introduced at a very early date to India and China. It is still seldom seen and little appreciated in the New World. Bush okra is grown in some regions principally for its commercial fiber jute, and thus competes with the better known jute source *C. capsullaris* L. It occurs wild in Africa and Asia, probably as an escape from cultivation, especially in open, damp areas. It is of major importance as a fiber in Bengal, but as a food, from the Middle East to Tropical Africa. The fibers are used in coarse twine, cloth and burlap bags.

Jute mallow is a vigorous, annual upright, branching, glabrous (or almost so), 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 to 5 cm. are produced in large numbers, especially during the short days. Many varieties are known. The vegetable types are smaller than the fiber types, and are more branched, but the leaves and shoots of all varieties are edible.

Figure 9. Mature plant of *Lithonia triangulare*.

The plant is propagated only from its seeds, which can be sown at any time of the year. The usual practice is to sow in excess and thin the plants to spacing desired. With time the plants reach more than a meter of height and 50 cm. in diameter. Closer spacing may be desirable, especially in order to provide abundant greens from small plants. Plants tolerate wide extremes of soil and are considered easy to grow. They profit from spring rains but are also drought resistant. In some climates branching is excessive, flowering occurs early and the lifetime of the plant is too short for convenient gardening. On the other hand, a first edible crop may be had as little as 4 weeks after planting. In Egypt, the first cutting is made after 2 1/2 months and subsequent cuttings are made each month.

The edible shoot tips and leaves are always eaten cooked. Their edible qualities are widely known but particularly appreciated in West Africa. There the shoots and leaves are combined in stews to be eaten with starchy paste. In India the shoots are cooked with rice. They are considered to be a tonic. The leaves may be dried and retained for future use, either as a tea or a cooked vegetable.

Corchorus requires little cooking for it rapidly softens and becomes mucilaginous, a characteristic unappealing to many persons. The flavor is very good. Varieties are said to differ in their cooking qualities and flavor. The protein content, particularly of older leaves, is excellent.

Other edible species of *Corchorus* are mentioned in the appendix.

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CHAPTER III

Some Fruits, Vegetables, and Ornamental Plants That Also Bear Edible Leaves

Edible green leaves can be found almost everywhere. It is difficult to imagine a place, except the ocean, the polar ice caps, and the barest deserts, where edible leaves cannot be found. Probably the majority of the species of flowering plants have not been tested thoroughly for edibility of leaves. Many leaves that might be poisonous or irritating, with proper treatment are perfectly safe. Thus, in the tropics, edible leaves are always in abundance.

Frequently the common plants around us bear edible green leaves. These plants, whether used as sources of other foods, for ornamenting our homes, or for shelter and shade, are overlooked for their values as sources of green leaves. While we spend extravagant amounts in the supermarket for fresh greens brought from long distances, potential food is wasted around us, or is thrown out with the garden clippings. With a knowledge of the edible green leaves of common plants around us, there may be no need of searching for greens outside of one's own backyard. Furthermore, these common green leaves vary in taste, and afford new thrills to the gourmet, when eaten raw or when cooked.

Vegetables

Common garden vegetables grown for other purposes often bear edible green leaves that can be harvested with minimum damage to the plant.

Zea mays L. (corn, Graminae) is of course grown for its edible seeds, eaten in their immature form on the spike, or in a variety of products after maturation. However, other parts of the plant are also edible. The young ears can be eaten raw, cob and all. Or they can be used as a salad ingredient. The tassel, while still enveloped in the leaves, is tender, delicious, and highly nutritious. The leaves are produced in sequence with each young leaf enveloped by the next older. These young developing leaves (Fig. 10) are extremely tender and delicious, and are edible either raw or cooked. Removing of the edible leaves of corn usually destroys the growing tip. Thus corn can be thought of as an emergency or luxurious source of edible green leaves.

Allium cepa L. (onion, Liliaceae) is not normally valued for its mature green leaves, although the leaves of young onions are often appreciated. The leaves of older onions are also edible but apt to be too strong for consumption raw. Cooking modifies the irritating substances, and, makes of onion leaves a flavorful pot herb that can be taken alone, but is particularly good when combined with meat dishes. In addition to onion, other species of *Allium* are frequently grown. Chives (*A. schoenoprasum* L.) are, of course, grown as a leaf-producing vegetable, but leaves of other species, including those wild, are equally edible. It might be wise to always cook any except very young onion leaves.

Zingiber officinale Roscoe (ginger, Zingiberaceae) and other wild and

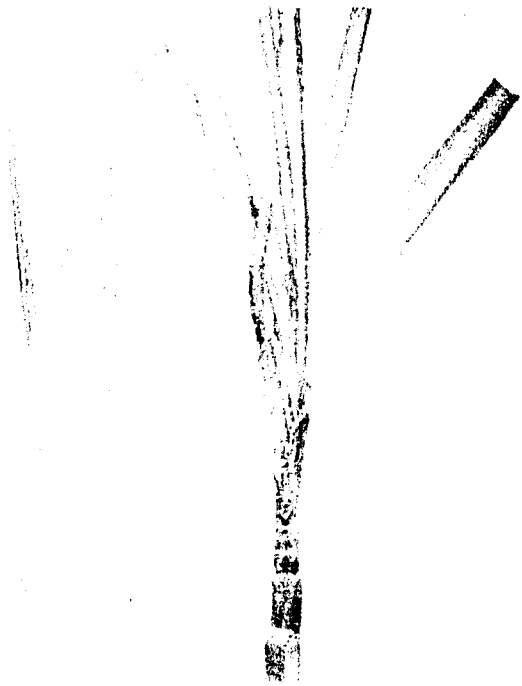

Figure 10.—The delicate edible inner leaves of corn.

cultivated Zingiber species produce edible, slightly spicy shoots which can be eaten. The shoot consists principally of the succulent young leaves folded around one another. On cutting and cooking, these separate like the leaf bases that form palm cabbage.

The family Leguminosae is particularly rich in species with edible green leaves. Those of practically all the edible species of beans, for example, are edible. The amateur should be cautioned, however, that the family also includes species with poisonous leaves. Species of legumes should be identified before their leaves are eaten.

Among the better known tropical vegetables, the pigeon pea (*Cajanus cajan* Millsp.) is known for its small flavorful seeds shelled fresh from the pod or cooked when dry. The leaves as well as the young shoots and pods are eaten cooked. The protein content of the leaves is high, making this a particularly desirable species. The plants resist drought and tend to produce even under very difficult conditions. The cooked leaves have a strong spicy odor, somewhat too much fiber, and a new flavor not agreeable to everyone.

Vicia faba L. (broadbean) is a species usually grown only at high elevations in the tropics. This useful vegetable, source of edible green and also edible mature seeds, is also used as a green-leaf source. The related species, *V. abyssinica* Steud. is used in the same fashion.

Vigna sinensis (Stuckm.) Savi ex Hassk. (Cowpea) is commonly cultivated throughout the tropics. Its edible ripe seeds are an important vegetable over wide areas. The long pods of some are especially tender and delicious. The young leaves are also quite suitable as cooked greens. The leaves of other *Vigna* species are also edible. On cooking they lose much of their color and soften excessively. The cooking odor is quite strong but the flavor of the finished dish is mild.

Pisum sativum L. (Garden pea) is widely grown in the temperate zone, where it is used for both its green immature seeds, and its dried seeds. The pea is not a tropical plant, and grows well only at cool sites at high locations in the tropics. The young leaves are quite edible and worthy of further trial.

The common garden bean or snap bean (*Phaseolus vulgaris* L.) is almost always grown for its edible immature pods or dried seeds. Many varieties are grown throughout the tropics, and suitable types are available not only for the highlands, but also for the coastal plains. Beans grow rapidly and provide a crop within a very short time. There is no real need to grow beans for their leaves, but the young leaves are edible and can constitute an interesting new dish to the sated gardener.

The leaves of many other beans are edible, including those of *Phaseolus coccineus* L., the scarlet runner bean, *P. limensis* Macf., Lima bean, and *P. aureus* Roxb., the mungbean.

Glycine max (L.) Merr. (soybean) is not well known in most parts of the tropics. Its real success has been as a dried bean in temperate zones, and it merits special attention by virtue of its high oil and protein content. Its protein has a very high quality. Varieties have been developed for the tropics, the immature pods of which are cooked as a green vegetable. It is not widely known that the young leaves are equally edible.

Many other less common edible legumes with edible leaves are listed in the appendix.

Hibiscus esculentus L. (Okra) is widely grown for the edible and mucila-

ginous pods. It is a vegetable particularly important in West Africa. By continuously harvesting the plants can be kept producing for many months. Like many of the related *Hibiscus* species, the young leaves are eaten. They have an agreeable sour flavor. The Indonesian species *H. manihot* L. is used exclusively for its leaves (Fig. 11).

The ferny leaves of the carrot, *Daucus carota* L., are perfectly edible, distinctive in flavor, and a welcome change in the diet. Young leaves, raw or steamed, are eaten with rice in the East Indies. There is no reason that once carrots have been purchased with tender edible leaves, that these should be discarded in favor of the roots. However, young leaves cause dermatitis to sensitive persons. The carrot is not well suited in lowlands of the tropics but some varieties do well at higher elevations with cooler temperatures.

Perhaps to many a person it will come as a surprise that the leaves of the solanaceous vegetables are also edible. The foliage of the potato (*Solanum tuberosum* L.) contains a poisonous alkaloid, and throughout the literature are frequent references to the poisonous leaves. Nevertheless, the young leaves of potato are sometimes eaten. Their protein content is twice that of the tuber. Another alkaloid bearing species of the same family is *Nicotiana tabacum* L. (tobacco). The young leaves of this common plant, grown in both temperate and tropical zones, are also edible. Some caution should be exercised in eating leaves of plants that yield alkaloids. The amounts normally used for a cooked dish should not be harmful. Cooking of questionable vegetables is always desirable.

Other valuable solanaceous vegetables useful for edible green leaves are the peppers. The leaves of *Capsicum annuum* L. (green pepper) retain their texture well on cooking, have a mild flavor with slight bitterness that is reminiscent of the green fruit. Leaves of *Capsicum frutescens* L. (tabasco pepper) give off a pungent aroma when they are cooked. Sufficient pungency remains in the firm cooked leaves to add a special appeal. In Malaysia the leaves of the weed *Lycium chinense* L. are eaten, particularly with pork.

Solanum melongena L. (eggplant) yields a fruit well-known throughout the tropics, and used in many kinds of dishes. As is frequently the case, the leaves, which are seldom used but which are perfectly edible, are more nutritious than the fruits. On cooking the leaves retain their texture. The fine hairs of the leaf are irritating to many people. The cooking water retains a spinach-like odor, but the leaves are not very flavorful.

Sechium edule Sw., the chayote, is frequently grown throughout the tropics for its pear-shaped fruits, which are eaten boiled or baked as a vegetable. It is less well known that this perennial vine has a starchy edible tuber, up to 5 kg in weight, raw or cooked. The tender young leaves and tips of the stems are valuable green vegetables. The follage contains fair amounts of iron, carotene, thiamine, riboflavine, and niacin. The tendrils tend to be fibrous and should be discarded before cooking.

The various species of *Cucurbita* (*C. moschata* Duch. ex Poir, *C. maxima* Duch., and *C. pepo* L.) collectively yielding pumpkin and squashes, are rich sources of varied food materials. The fruits can be eaten at practically any stage from the flower until maturity, although the optimum stage for edibility varies. Squashes are not common in many parts of the tropics. The popular varieties in the temperate zone are seldom adequate for tropical

Figure 11.—The sulfur colored leaves of *Hibiscus manihot.*

lowlands. However, locally adapted varieties, often with many poor characteristics but good adaptation can be found. The butternut squash is usually successful in warm climates. Of all species and varieties the young leaves are edible.

Field and Plantation Crops

Field and plantation crops used for non-food purposes sometimes also produce edible leaves. For example, the common source of animal feed, alfalfa (*Medicago sativa* L., Leguminosae) is also a source of edible leaves and shoot tips. These have the advantage of being rich in methionine, an essential amino acid often in short supply in other plant foods. Alfalfa leaves are eaten in India. The dried, powdered leaves are now being promoted as a health tea. Ignorance and prejudice make alfalfa an unknown food crop for humans in most areas.

The oil crop, sesame (*Sesamum indicum* L., Pedaliaceae) of African origin, but now cultivated chiefly in India, Asia, and now South America as a source of cooking oil, is also a source of edible leaves. The plant is an erect annual herb raised from seed. The leaves are quite hairy, which for most persons produces an uncomfortable feeling in the mouth. Nevertheless, the young leaves of this and of several related species are regularly eaten.

Another oil and nut crop of commercial importance, the peanut (*Arachis hypogaea* L., Leguminosae) of tropical South America, but now distributed throughout the tropics and temperate zones is frequently utilized as forage, hay, or silage. However, the young leaves and tips are equally suitable as a cooked green vegetable.

Ornamentals

In addition to herbs commonly found in gardens, many of the ornamental shrubs planted around the house are valuable sources of edible green leaves. The edibility of these leaves is seldom known to the gardener, and thus in time of scarcity or starvation, the knowledge of these edible leaves would be especially useful.

Acalypha species such as *A. hispida* B. Wm. f. (Copperleaf chenille) and *A. wilkesiana* Muell. Arg. (Painted copperleaf) are edible leaved examples of the family Euphorbiaceae known not only for its poisonous species, but also as a family the leaves of which are rich in protein. These are shrubs that thrive in full sunlight and develop rich anthocyanin coloration of leaves. The leaves are frequently variegated. Especially useful in foundation and hedge plantings, these East Indian and Pacific Island plants are now very common throughout the tropics. The plants are propagated from cuttings.

Ardisia is not too common a shrub but has been widely distributed from India. Leaves of a number of species are edible, including the commonest *A. solanacea* Roxb. Many other species also bear edible leaves. These are eaten raw as well as cooked. The rather small flowers are followed by attractive berries. Propagation is possible by air layers when seeds are not available.

Some Bougainvilleas are used as sources of edible green leaves in West Africa. Are all the species equally edible?

Cassia alata L., or ringworm senna, ia a rather small shrubby example of its genus from the West Indies and South America (Fig. 12). The leaves contain chrysophonic acid and are widely used in treating skin diseases. The flowers are rather unusual in that they occur in dense, erect spikes, and are covered until maturity with yellow, petal-like bracts. It is a vigorous, floriferous water-loving species, that responds to pruning by more vigorous flowering. The leaves are long and pinnately compound. The bush is normally propagated from seed. Only the youngest leaves are used as food.

Catharanthus roseus (L.) Don, commonly known as Madagascar periwinkle, is a very attractive, freely blooming, slightly woody species commonly seen in tropical gardens. It is propagated by cuttings or from seeds. The young leaves are sometimes used as a vegetable, but older leaves contain a poisonous alkaloid.

Hibiscus rosa-sinensis L. is the most common of the tropical ornamental *Hibiscus*, and indeed one of the best known ornamentals of the tropics. Known as Chinese Hibiscus, it has been hybridized to produce many beautiful new forms. The unimproved types are extremely vigorous, and are often propagated by thrusting large stakes directly into the ground. Varieties that root with difficulty are often rooted with the help of hormone treatments, or are grafted on vigorous stocks. The leaves of many species of *Hibiscus* are edible. Because this species is so common, so vigorous, and is often used as an ornamental hedge, it should be a particularly valuable emergency source of edible greens.

Codiaeum variegatum Blume is the common garden croton from Southeast Asia that is common to all tropical areas. It is highly regarded in the garden for its brilliant variegated leaves, its year-round attractiveness, its resistance to pests, and its ease of culture. It is a plant with supposedly medicinal purposes, and is used especially to bathe the mother after childbirth. Young leaves especially of yellow varieties, have a mild, nut-like flavor, but palatability varies with variety.

Euphorbia pulcherrima Willd, the common poinsettia (Fig. 13) so much appreciated for its bright red foliage at Christmas time, is poisonous in the natural state. The latex from leaves or stems may irritate and blister sensitive skin. It causes eye inflamation and should not be swallowed. It is sufficiently caustic to remove hair from the body, but is mixed with oil for this purpose. Nevertheless, the young leaves of this easy-to-grow ornamental are not only edible, but highly nutritious. They are never eaten raw. A native of tropical America, the poinsettia is widely distributed and well-known. It grows rapidly from woody cuttings. Because of its l x habit it can be improved by the pruning necessary at harvest. The warning must be given that gathering leaves may lead to dermatitis, and because it is poisonous, the plant should be kept from children who are apt to chew it.

Jatropha curcas L., The Barbados nut or the physic nut, is well known, well distributed, and grown not only for ornament but also for the oil of the seeds. The dark-green foliage is attractive, and the species is well adapted to poor and dry soils. The poisonous qualities of seeds and oil are well known, and yet the young foliage is cooked and eaten in Indonesia.

Closely related to *Jatropha* is *Cnidoscolus chayamansa* Mc Vaughn (chaya or tree spinach) popular in Mexico and Central America, and intro-

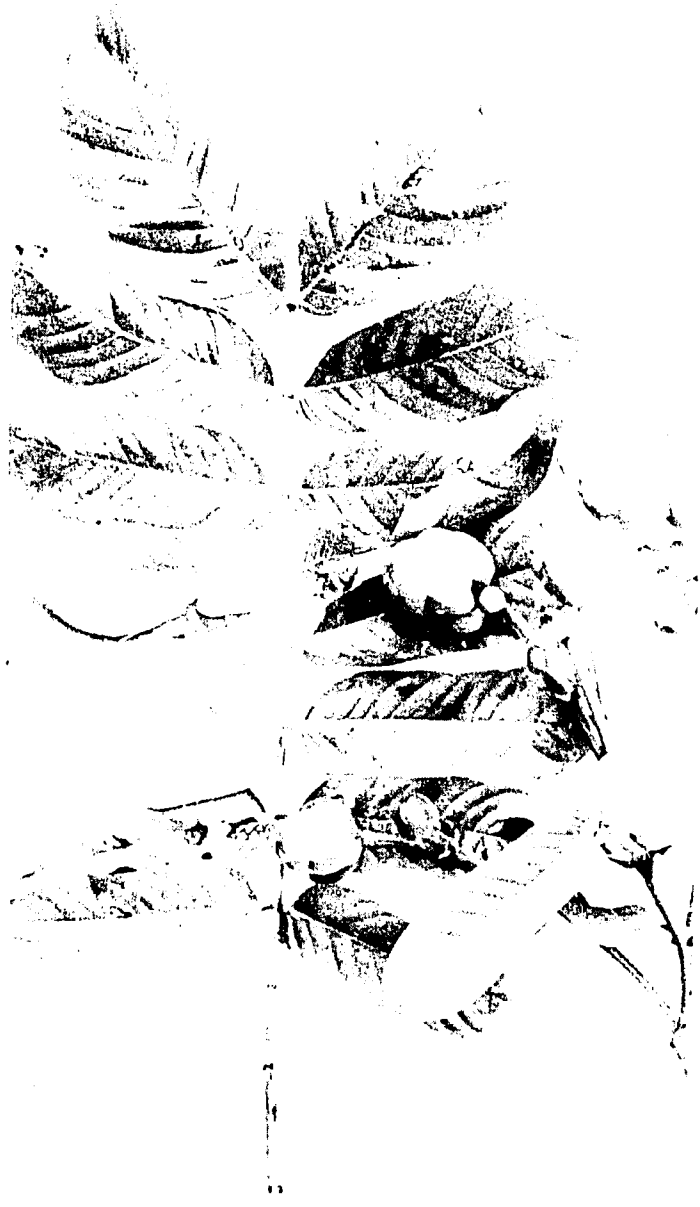

Figure 12.—*Cassia alata*, ringworm senna, a medicinal and edible leaf.

Figure 13.—Leaves of *Euphorbia pulcherrima*, the poinsettia, a debatable species.

duced into Florida (Fig. 14). This vigorous shrub yields edible young leaves and shoot tips which have been reported to be high in protein. The leaves are also rich in calcium, iron, carotene, riboflavin, niacin, and ascorbic acid. The presence of stinging hairs make the use of gloves desirable when harvesting leaves, but the stinging property disappears on cooking. Cuttings of plants with few hairs are usually selected for propagation.

The common castor bean, *Ricinus communis*, is often grown as an ornamental, although its height and rapid growth do not fit it for the typical garden. The oil from the poisonous seeds is used for many purposes, and the plant is therefore grown commercially. The young leaves, while edible, contain the poisonous alkaloid ricin, and therefore must be boiled sufficiently in at least two changes of water to render them safe. The water, of course, should be discarded.

Fruit Trees

Throughout the tropics there are a very large number of trees that bear edible fruits. It is not difficult to make a list of 300 species, and in addition many more of minor importance are found in restricted areas. Nevertheless, the majority of the fruits and nuts of the tropics come from a very limited number of species. These species that are found throughout the tropics, are those that merit special attention here.

The leaves of citrus fruits (Rutaceae) often contain essential oils and flavonoids that impart characteristic pungent odors and tastes. These leaves are not eaten. Nevertheless, several minor species of the family do produce edible leaves (see appendix).

The leaves of the banana (*Musa* sp. and hybrids, Musaceae) once they have emerged from the pseudostem toughen up rapidly, and are more suitable for wrapping foods than to be eaten themselves. Nevertheless, within the pseudostem the developing leaves are much more tender, and can be eaten either raw or cooked. This portion is often called the heart. To extract the heart the trunk can easily be opened with a sharp machete. In addition to the heart, the flower bud of the banana can be eaten after boiling. The soft portions near the base of the flower bracts are eaten as are those of the bracts of globe artichokes.

Fruit bearing trees of the family Anacardiaceae also bear edible leaves. *Anacardium occidentale* L., for example, is the source of the cashew nut and of the cashew apple, the fleshy peduncle of the true fruit. It is a species especially adapted to poor soils and dry areas. Although it is native to Brazil it is widely planted throughout the tropical world, frequently in coastal areas, as a source of nuts for the international trade. Since the shell of the nut contains an irritating oil similar in structure and effects to that of poison ivy, the raw nuts should not be bitten into until the nut is roasted. The young leaves (Fig. 15), are commonly cooked in Southeast Asia, but are too astringent for regular use.

Mangos, now so displaced from their native habitats in India and Southeast Asia, are found everywhere throughout the tropics. Most mangos per-

Figure 14.—Young plants from cuttings of *Cnidoscolus chayamensis.*

Figure 15.—Leaves of *Anacardium occidentale*, the cashew.

form best in a moderately dry climate. Nevertheless, tolerance to rain varies, a and some varieties thrive and produce even under rain-forest conditions. The fruits, which are usually seasonal, have sometimes been described as the peaches of the tropics. They are incomparable in flavor. Mango is an evergreen tree. New leaves are produced in several vigorous flushes of growth each year, usually beginning with the rainy season. These young leaves are frequently rose-colored or bronzed with anthocyanin. On cooking them the anthocyanin is boiled out leaving the leaves pale-green. The cooked leaves tend to hold their shape and texture, and present an attractive appearance. The flavor is more or less resinous, and will not agree with every palate. The leaves of distinct varieties vary in their suitability. Some study to determine the best varieties as sources of edible leaves would be desirable.

A number of species of *Spondias* bear edible fruits, and it is probable that leaves of all species are edible. Young leaves of *S. dulcis* Forst are eaten raw or cooked. The leaves of *S. purpurea* L. are eaten raw, and those of *S. pinnata* Kunz are cooked. The fruit-bearing *Spondias* species vary in size. The leaves are typically pinnately compound. The fruits are borne in clusters, and vary in length from 2.5 to 8 cm. Most are rather sourish, but sweet, improved varieties have been developed. *Spondias* is propagated by seeds or from large cuttings. However, the better varieties are best multiplied by budding.

Leaves of the soursop (*Annona muricata* L., Annonaceae) are edible. This and its many relatives are mostly small trees, some adapted to dry and others to wet forests. Their soft, spine-covered fruits yield a pulp that varies from quite sour to agreeably sweet. The young fruit many also be cooked as a vegetable. *Annona* species are easy to grow, usually from seed. A few improved varieties and hybrids have been developed. On cooking the soursop leaf, a good texture is retained. The cook pot emits a rich odor. Cooked leaves are slightly bitter, and do not have much flavor.

One of the rarest of tropical fruits in the Western Hemisphere, the durian (*Durio zibethinus* Murr., Bombacaceae) of Southeast Asia, is noted for its strong odor that appears pleasant enough to those who like the fruit but is extremely offensive to all others. The large fruit is covered with sharp, pyramidal spines. The soft pulp around the seeds is eaten raw or made into candies. This is a tall tree from which foliage cannot easily be taken (Fig. 16), but the young leaves of durian are sometimes eaten after cooking. Other species of *Durian* also bear edible fruits, and certainly the leaves of some of these must be edible.

It is not surprising that the fruit-bearing species of Euphorbiaceae also bear edible leaves, as this is so typical of many members of the family. One of the best known is the Bignay (*Antidesma bunius* L., Spreng) from Southeast Asia. The tree is large, evergreen, and bears clusters of berries which turn from green to white, to red, and finally to black as they mature. The fruits are small and large-seeded but can be used for jams and jellies. On cooking the young leaves turn an unattractive brown but retain their texture. The flavor is slightly sour, but otherwise somewhat similar to artichoke.

Two species of *Phyllanthus*, another genus of Euphorbiaceae, bear edible fruits and leaves. The Otaheite Gooseberry or Grosella (*P. acidus* L., Skeels) produces large quantities of yellow, waxy, scalloped-edged fruits.

Figure 16.—The edible leaves of the durian, *Durio zibethinus.*

When cooked, the fruits turn bright red due to the transformation of a leuco-anthocyanin to its colored form. This is a small, rapidly growing tree that does well in dry areas. The tree is usually propagated from seed. Its cooked young leaves are neutral or mild in flavor, but somewhat fibrous.

Another species, *P. emblica* L., is not as common. The round greenish, angled fruits are high in vitamin C. The leaves of this species, though edible, are very small. On cooking there is little odor, but the cooking water becomes an unappetizing suspension of yellowish particles. The flavor is extremely bitter and would appeal to very few people.

The common tamarind (*Tamarindus indica* L., Leguminosae) is a tropical tree from Africa now widely distributed, and particularly well known in India (Fig. 17). Wherever it is grown the rusty colored pods are harvested for the thick pulp found around the seeds. This is usually quite sour, due to the high content of tartaric acid. Sweet forms have been described. The pulp, when mixed with water and sugar, produces a pleasant drink not unlike lemonade. It is also widely used in confections, condiments, and chutneys. In addition to the pulp, the seeds are edible after toasting or boiling and removing the shell. They can also be made into a flour. The dried pulp is marketed for use in meat sauces and chutneys.

The tamarind is a handsome tree with hemispherical shape that grows best in dry areas. It is frequently seen along coasts, and in sandy soils, which suggests that it resists saline conditions. Trees are usually grown from seeds, but superior varieties are budded or grafted.

Once cooked, the young leaves lose their color. The cooking odor is not pronounced. The flavor is agreeably sour and quite similar to that of the fruit. Thus, this type of leaf is best cooked with other, less flavorful vegetables. Both the leaves and flowers are eaten fresh in salads or cooked in curries, soups, and stews.

The family Moraceae furnishes several species with edible leaves. Many wild figs (*Ficus* sp.) bear edible leaves and shoots. Some species of *Artocarpus*, the genus of the breadfruit and the jackfruit, yield young leaves that are good to eat. Perhaps the most important fruit species with edible leaves is the common mulberry, *Morus alba* L.

The mulberry is a rapidly growing tree from China that is more common in temperate than in tropical zones. Nevertheless, varieties are known that perform well even at sea level in the humid tropics. Selected varieties bear very excellent fruits. It and the related *M. indica* L. are the sources of leaves traditionally grown as feed for silk worms in China. All parts of the tree have medicinal uses in China.

The leaves are often used as cattle feed. The young leaves (Fig. 18) are edible and are consumed principally by nursing mothers. On cooking, the young leaves become very soft but retain their color. The flavor is mild. The fine pubescence may be slightly unpleasant.

The rose family, Rosaceae, includes a number of tropical fruits, but few species of which the leaves are eaten. An exception is the raspberry, *Rubus rosaefolius* Smith, a species introduced from the Himalayas, but now widely distributed and in fact excessively weedy in some high rainfall areas. The foliage is light green in color, and the berry red on maturity, with little

Figure 17.—A branch of tamarind, *Tamarindus indica*, with edible tips and young fruits.

Figure 18.—Young leaves of the mulberry, *Morus alba.*

flavor. It is propagated chiefly by root suckers which are produced in abundance. Red young leaves of rose bushes (*Rosa*) are edible raw or cooked.

Among the many fruits of the Sapotaceae, one of the best is the sapodilla or nispero (*Achras zapota* L.). The tree is very common in tropical America, especially Mexico and Central America, where it serves as a source of chicle for the manufacture of chewing gum. It is a handsome tree often planted as an ornamental because of its dense, deep-green foliage and an attractive symmetrical shape. The rust-covered fruit contains a soft, brownish pulp surrounding a few seeds. The seedlings of the sapodilla are often grafted to propagate the excellent varieties that have been developed. Only the very young leaves are considered edible.

Papayas, *Carica papaya* L., are grown chiefly for their fruits. Although these are eaten ripe and fresh, the green fruits can be cooked as squash. Many other uses have been described. The interior of the stem is soft, and may be eaten raw. Dried leaves are used as a tobacco substitute, and can also be beaten in water to form a soap substitute. The leaves may be cooked as a green vegetable. They should not be eaten raw because of the possible danger from both the alkaloid carpaine, and the enzyme papain. As a precaution, older leaves should be thoroughly boiled, changing the water at least twice. Younger leaves are not harmful. Flowers are also cooked and eaten, generally, with the leaves.

Upon cooking the leaves have a pleasant chartreuse color and retain their form and texture. The cooked leaves have a strong, bitter taste that is disagreeable to some people. In addition, they have a distinctive flavor reminiscent of asparagus. The tender petioles may be eaten, but are more bitter than the blades. Papaya leaves are more appropriately served in stews than as a separate dish.

Methods of cultivation need not be given in detail here, for the plant is well known. Seeds germinate in 3-4 weeks. Seedlings may be established either in separate containers, or if protected, directly in the desired location in the field. The plants grow rapidly and begin to bear fruit in less than a year. One or two leaves per plant harvested occasionally is not likely to interfere with fruit production. Since some plants are male, and therefore bear no fruits, these can be used for edible leaves, if desired. The growing tip should not be removed for this will disfigure the plant. The plants can live for several years, but their continued growth will eventually place new leaves out of easy reach.

The leaves of coffee, *Coffea arabica* L., of the Rubiaceae are edible. On cooking they have a strong brown color, a good texture, and a rather neutral flavor with only a touch of bitterness.

CHAPTER IV

Common Weeds with Edible Green Leaves

Weeds are generally defined as herbaceous plants. Among their many characteristics are that they appear wherever man has disturbed the soil, they grow rapidly and often steal the fertility of the soil from desirable species, they mature large quantities of seed, and they are difficult to control. Weeds are often described as undesired plants, plants growing out of place, or plants which are a nuisance. Both the characteristics and the definitions of weeds emphasize that they are plants closely related to man. As is the case of so many of the activities of man, weeds are ephemeral. They come and go as man disturbs the soil. Just as man has traveled, and dominated the land, so have weedy species benefited from his activities. Many weedy species are known throughout both temperate and tropical zones, or have races so distributed.

Trees and shrubs are seldom weeds. Those species that grow rapidly may be said to be weedy but they lack an essential characteristic, an intimate relation to man and a dependence on his activities. Occasionally transplanting a species from one region to another permits weedy tendencies to manifest themselves, but such weedy trees seldom become the plagues that annual plants can be.

Weeds probably evolved by a number of mechanisms. First, weeds are species adapted to naturally disturbed areas where fire, flood, drought, deforestation, or other activities have cleared the land. They are species that constitute the pioneers in ecological succession. After weeds have covered the ground, other, more durable species, are eventually established. As new species cover an area, the weedy species gradually disappear. Species of this sort are weedy because either nature or man has established abnormal ecological situations which correspond to those that occur naturally.

A second group of species are those that are adapted more specifically to the situations normally created by the activities of man, but are not necessarily involved in the ecological succession. Such species grow in soil disturbed by man. They follow the plow. They use the fertility added to the soil, whether it be in the cultivated field or the garbage dump. Then, to avoid extinction, they produce seed rapidly and disappear.

Still a third group of species are intimately associated with the domestication of wild plants. Man carried many plants from the wild to his dwelling in order to use them easier. With generations of use, adaptation to the special environment grew. The modified plants often hybridized with their wild relatives, and the hybrids showed new variations. Sometimes in close proximity to the cultivated species, a weedy species evolved which competed with it. The weedy species might have shared many of the characteristics of the cultivated species. Sometimes the cultivated species has died out, but the weedy species has continued.

Because of their origin so close to the activities of man, many weeds have been discovered to be edible, and indeed are used locally as pot herbs throughout the world. The use of weeds as food has a double advantage, something useful is achieved, and the weeds are removed from sites where

they might compete with cultivated plants. In most areas of the world, weeds, during their season, offer the most available food, and that which is often most despised. It should be mentioned, however, that many weedy species are not only persistent, but are often obnoxious due to other qualities, including the presence of poisonous substances, of irritating hairs or spines, or barbed seeds that are caught in the clothing. These adaptive qualities may be useful for the survival of weedy species, but also suggest to the amateur that some caution should be exercised in testing the food values of unfamiliar species.

Acanthaceae

Justicia insularis T. And. (Acanthaceae, no English common name) is the best known of the various species of this genus cultivated or fetched from the wild in Africa for their edible leaves (see appendix). Two species, *J. quinque-angularis* Koenig, and *J. precumbens* L., are eaten in India. The genus is common throughout the tropics and includes a few ornamental species. Some species have astringent characteristics and are used for local medicines. Most are herbaceous or only slightly woody. The edible species are very little known outside of their native regions, but merit some further trial.

J. insularis is a small herb (Fig. 19) that branches freely at the base producing attractive clumps with dark green leaves. It is rather a slow-growing but definitely seasonal plant that dies back during the dry season after profuse flowering. The short-petioled rather circular leaves are finely pubescent, as is the squarish stem. The species should make an attractive summer garden plant.

The leaves and tender stems are eaten as a pot herb or spinach. They give off a strong but pleasant odor when cooked. The cooked leaves retain much of their dark green color. They are of good texture but tender. The hairs of the stem and leaves are a minor irritant in the mouth. The flavor is pronounced, and likeable, but sometimes a little bitter. Stems are slightly fibrous, and add little of value to the cooked dish.

Justicia can best be grown from seeds, which germinate and grow slowly.

A few of the clock vines (*Thunbergia* spp.) bear edible leaves. The species *T. alata* L. is widely distributed and easily recognized by its yellow or orange flower with dark throat, and its winged stem. The leaves are eaten in the Congo (Fig. 20) but their edibility is practically unknown elsewhere.

Compositae

Leaves of many weedy species of the family Compositae are edible, but their edible qualities are seldom well known. Edible tropical species of *Lactuca* (lettuce) will be mentioned in a later chapter. Some of the more tasty edible weeds are surprisingly common.

Bidens pilosa L. (Spanish needles, Margarita) is a very common weed of tropical America that has spread throughout the tropics. Because of its needle-like seeds which readily adhere to clothing, it is easily transported. Moreover, for the same reason it is a nuisance wherever it grows. It is a diffi-

Figure 19.—A clump of the edible weed, *Justicia insularis*.

Figure 20.—Leaves and flowers of *Thunbergia alata,* susana.

cult weed to eradicate because it grows as well in waste places as in cultivated fields and re-establishes itself quickly, even in areas where it has been eradicated with chemicals. Perhaps it is its perverse nature that led Julia Morton (1962) to study it thoroughly for its possible worthwhile uses.

As pointed out by Morton, this weed is valuable as a source of nectar for bees, in sparse amounts it is eaten in fodder, or it is eaten fresh by rabbits and chickens. The older foliage is somewhat purgative. It is also used medicinally for a variety of purposes. As a food plant Spanish needles is used chiefly in Africa, but it is known and consumed also in tropical Asia.

The plant is a herbaceous, annual, erect, branching, with opposite serrate compound leaves (Fig. 21). In addition the stem is angular and finely pubescent. Where the stem touches the wet ground, roots can form at the nodes, and thus the plant can expand its area. This trait, and the ability to seed rapidly leads to the formation of extensive weedy areas at times, that appear more like seeded ground cover. The flowers are abundant, with yellow disks (ray color varies). The black, long seeds stick to clothing by means of the remnants of the sepals.

Morton (1962) has also traced the utilization of the species as food through a thorough review of the literature. Peoples in widely scattered regions have used the plant to advantage, as a boiled leaf, and as a tea. The young shoots are sometimes sold on the market in Malaysia.

Morton has also investigated the characteristics of the leaf as a cooked vegetable. We have independently checked and confirmed her observations. The tender tops of the wild plant are normally taken. Older leaves have a more pungent odor disagreeable to some people. Upon boiling, the greens retain their pleasant dark green color. They may be eaten as a vegetable dish, used cooked in salads (but not raw), or combined in a stew. The taste is strong but pleasant, and may leave an aftertaste. The leaves may also be dried, preserved, and cooked later.

Because of the assets of this species, its year round availability, attractive appearance, and usually readily acceptable flavor, this species ranks as one of the best of the weed sources of edible greens.

Vernonia species (bitter leaf) which occur throughout the tropics, bear edible leaves, which are often used in local cooking. One species, *V. amygdalina* Dal, is a popular leafy vegetable from South to West Africa. It is probably of very ancient origin, and is both a cultivated plant and a spontaneous weed. The more cultivated races are almost free of bitterness. Other species occasionally used as food are either wild or weedy.

Vernonias vary from annual to perennial herbs, vines and shrubs. There is sufficient variation among the edible species to make generalization difficult. The principal species, *V. amygdalina*, has long ovate, grayish leaves.

Because of the bitter taste common to all species, Vernonias have found a wide usage in folk medicine. Most of their usages do not seem to stand up under trial, however. A glucoside has been found in the seeds of some species.

Except in the case of the sweet varieties, the young leaves are usually not used in large quantities, but are rather more like a condiment, which gives a bitter taste to other foods, particularly meats. It is quite possible that the leaves of all species are edible. Many would be too bitter for normal consumption, however.

Figure 21.—*Bidens pilosa,* Spanish needles, is a widely distributed edible weed of the tropics.

Convolvulaceae

The leaves of many of the common weedy species of the family Convolvulaceae are edible. This family, a large one of 1000 or more species, is widely distributed and well known. Nevertheless, a few species can be distinguished as world travelers, and are found throughout the tropics. Most of these have been tested and some found edible. Leaves of many of the inedible species are not poisonous, but their fine pubescence renders them unpleasant to the palate. The seeds of some species of the family contain hallucinogenic alkaloids, but so far these have not been shown to occur in the leaves.

A full list of edible species mentioned in the literature is given in the appendix. However, some of these species are not widely extended nor weedy, and need not be mentioned here. Some of the better known species follow:

The beach morning glory, *Ipomoea pes-caprae* Roth., occurs on sandy beaches throughout the tropics. Its succulent, glabrous, circular leaves with notched apex make it easy to recognize (Fig. 22). While a scraggling, running vine under circumstances of poor nutrition, it is capable of forming a handsome ground cover when well cared for. The large, pink flowers which open in the morning are attractive. The thick stems are similar to those of sweetpotato, as is the flavor. The plant tolerates salt water, and may accumulate sufficient salt to give the leaves a salty taste. Although the herbage is sometimes fed to pigs and cows, it is said to taint the milk, and ultimately to cause illness if not fatality. In the Hawaiian islands this species is recognized to be useful only in times of famine. Regular consumption produces dizziness. The edibility of leaves of another and possibly related beach morning glory, *I. stolonifera* Poir, has apparently not been tested.

The moonflower, *Calonyction aculeatum* House (*Ipomoea alba* L.), occurs wild in the tropics, and is frequently planted as an ornament in the temperate zone. Its flowers are large, showy white, and fragrant. The species grows best in disturbed areas including roadsides and abandoned fields. The moonflower is a vigorous climber, and needs an appropriate arbor to display the flowers and to permit collection of the young leaves. The plants, even when weedy, prefer wet areas, and are often found along river banks. The young leaves and the calyces of the flower are cooked as a vegetable in Africa, India, and Indonesia or are used in vegetable soup in China. They may be used either fresh or dried. Contact with the plant may cause dermatitis.

Other common species with edible leaves that merit attention because they are easy to find include the cypress vine, *Quamoclit pinnata* Boyer, with its white or red salverform flowers, *Merremia umbellata* L., which produces yellow flowers, and *Ipomoea digitata* L.,recognized by its deeply, palmately cut leaves. The latter species produces a tuberous root with purgative properties. *Ipomoea eriocarpa* R. Br. is used in India as a leaf vegetable.

The possible edibility of leaves of the species most similar to the sweetpotato, *I. triloba* L., *I. tiliacea* (Willd.) Choisy, and others merit investigation. Scattered reports in the literature prove very hard to verify.

Figure 22.—Foliage and flower of the beach morning glory, *Ipomoea pes-caprae.*

Cucurbitaceae

Momordica charantia L. (Balsam pear, cundeamor), is a widespread species known throughout the tropics and the subtropics where it is often weedy and not utilized, but which approaches a cultivated state in still other areas. The cultivated and semi-cultivated races have fruits which are large and attractive. As pointed out by Julia Morton (1967), it is edible, medicinal, and toxic.

Balsam pear is a vigorous tropical vine that grows from seed either as an annual or perennial. The rather thin stems are grooved and slightly pubescent. The leaves are deeply divided into 5 or 7 lobes (Fig. 23). The flowers are yellow, 2-5 cm in diameter, and somewhat attractive. As in the case of many cucurbits, both male and female flowers are produced. The fruits develop rapidly. They are spindle shaped, and somewhat spiny. As they grow they change from green to yellow to pale orange. The ripe fruit splits and twists, revealing the seeds surrounded by a red aril. The seeds are attractive to birds and thus are readily distributed.

Many parts of the plant are used as food or medicine. Children suck the sweet pulp from the seeds, although sometimes they are cautioned to not eat too much. The immature fruits are sometimes boiled, without the seeds. The cultivated varieties are used in oriental cookery, before maturity, but they must be processed carefully to eliminate their bitterness.

The tips of the vines are marketed in Southeast Asia, where they are generally cooked with vegetables, meat, or fish. The small fruit is also preserved in brine or pickled.

On cooking considerable bitterness is removed from the leaf. It may be necessary to change the cooking water. The leaves retain a good color and a firm texture, with little of the bitterness of the uncooked foliage. The flavor is mild and unusual. The stems are mostly too tough to eat.

Probably much remains to be learned of the toxic qualities of Balsam pear. The fresh juice from the foliage is a powerful emetic, probably removed or destroyed by cooking. Eating the ripe fruit has caused serious purging and vomiting, as well as death in extreme cases. The toxicology has been reviewed in Morton's paper.

Cruciferae

The leaves of most species of the mustard family, Cruciferae, are edible, but some are excessively pungent. The family is second only to Compositae as a source of cultivated green leaf vegetables. The commonest species, chiefly of the genus Brassica, are familiar vegetables in the temperate zone, but grow only under special conditions in the tropics (see later). The edible weedy species include native tropical species, and temperate zone weeds which have been introduced and have become adapted. Edible parts include young shoots and tips, green pods, and sometimes ripened seeds. Most are eaten either raw in salads or cooked.

All of the cruciferas species share a common flower structure based on four sepals, four petals, and six stamens. The fruit is a dried capsule of one chamber.

Figure 23.—Leaves and mature fruit of the wild balsam pear, *Momordica charantia.*

It should not be necessary to name all the edible species here for they are found in the appendix. Some are fleshy herbs found along the beach (sea rocket, *Cakile fusiformis* Greene). Many are tolerant of dry conditions (*Brassica* species). Still others prefer moist places (*Lepidium virginicum* L.) or even the environment of running water (*Nasturtium officinale* L.). Wild *Brassica* species are abundant, and freely used, especially in Africa and India. Several species of *Lepidium* with edible leaves are known. Few countries are without examples of these pungent plants.

Graminae

The grass family is one of the most important to man, not only directly as a source of grains, construction material (bamboo) and sugar, but also indirectly as forage and fodder for domesticated animals. Very few species, however, can be used as a source of edible green leaves. The rather fine, long leaves preclude such usage, for they are reinforced by supporting fibers that inhibit digestibility. In a few cases, especially with respect to the larger and more vigorous species, the developing leaves, either recently unfurled or still folded in the sheaths of older leaves, are eaten as at least an occasional food. Entire young plants from seed, or the rapidly growing shoots from an underground rhizome are often eaten.

Perhaps the most spectacular of the edible grasses are the bamboos. The rapidly growing sprout or shoot of many species is edible. Others, while bitter, can be processed to an edible state. The shoot, however, cannot be considered a leaf and need not be considered further here.

Among those species of which the unfolded leaf may be eaten are *Saccharum officinarum* L., sugar cane, and *Zea mays* L., corn, which was previously mentioned. A complete list including bamboos is found in the appendix.

Leguminosae

Many of the common weeds of the family Leguminosae bear edible leaves. Those mentioned here are only the most common. Probably the edible qualities of many other species of this large family remain to be discovered.

The jequirity bean, rosary pea, or jumbie bead, *Abrus praecatorius* L., is a woody vine known chiefly as a source of red seeds each with a black spot. These are often made into necklaces and sold to tourists, throughout the tropics. The seed, however, is deadly poisonous, and death has occurred through ingestion of a single seed. The jumbie bead is a pestiferous weed, distributed by birds. It is found chiefly in abandoned fields, thickets, and fence rows. The very young leaves and shoots of this unlikely weed are sometimes eaten, or chewed raw for their licorice flavor.

Clitoria ternatea L. (Streaky bean) is a common, weedy vine sometimes grown as an ornament for its blue and white flowers, and also used as a green manure crop; it is also a source of edible leaves. Under favorable conditions the species is extremely weedy, and may cover with vines foliage of all other plants. Although of South American origin, it has become established throughout most of the tropics. The flowers are cooked with rice to color it. The seeds are quite poisonous.

Many species of *Crotalaria* produce edible leaves. In contrast, others are often poisonous, and kill slowly, even long after the leaves are eaten. Many of the species are used as green manure crops. Plants are herbaceous and slightly woody. Their flowers are yellow and usually attractive. By themselves they seldom form pure stands, but their weedy nature is suggested by the man-made habitats where they are usually found.

Other genera containing edible weedy species irregularly distributed throughout the tropics include *Desmodium*, *Mucuna*, *Phaseolus*, *Tephrosia*, *Vicia*, and *Vigna*.

Because leguminous plants are everywhere, further studies of the edibility of their leaves would appear justified. Nevertheless, extreme caution must be practiced, as this is one family that also contains a large number of poisonous species.

Malvaceae

Several species of the genus *Sida* (wireweed, escobilla), are used as green leaf sources. *Sida* is a genus well spread throughout the tropics, but particularly rich in species in Central America and the Caribbean. *S. alba* L. is used as a food in Central Africa. *S. rhombifolia* L. and *S. humilis* Willd. var. *moriflora* are common weeds that are cultivated in Central America and South America for shoots and leaves. Without doubt many other species are edible, but are not recorded in the botanical literature. The various species differ from low herbs to semiwoody shrubs. The stems tend to be tough and wiry. One species in particular, *S. rhombifolia*, is grown in Africa for its fibers. According to the species, the flowers differ in size. They are usually yellow or orange. A many seeded capsule is produced. *Sida* is a rather prolific weed and constitutes a serious nuisance wherever it is found.

Another weed of the Malvaceae, *Urena lobata* (cadillo, aramina) is particularly obnoxious because of its small capsules with curved spines which adhere readily to clothing or animal fur. This African species is now well distributed throughout the tropics, and where it occurs abundantly, it is difficult to eradicate. Although an annual species, it is rather woody. In the upper parts of the Amazon river the fibers are extracted and used chiefly in the construction of bags. With its large, pubescent leaves and white or pinkish flowers, it is an attractive plant when sufficiently small. The young leaves are edible. Several closely related species occur that merit trial under appropriate circumstances.

Piperaceae

In the family Piperaceae several common weedy species of value are found. The small, succulent herb *Peperomia pellucida* (L.) HBK. is commonly found in very wet places, including greenhouse benches and flower pots (Fig. 24). It also grows well in the cracks of walls or in rocky areas. It is seldom obnoxious, and in fact is even grown occasionally as an ornamental. The plant is used as a pot herb, or the leaves can be used in salads. In the West Indies the leaves are also brewed as a tea. Other less common species are probably also edible.

Figure 24.—*Peperomia pellucida*, a common edible weed of greenhouses.

Few pepper species bear edible leaves. Exceptions are the herbaceous species *Piper umbellatum* L. and *P. stylosum* (also named *Heckeria*). The species *P. betle* L. merits mention here because though not a weed, the species still exists in the wild, and its leaves are widely used as part of the betel quid that is chewed throughout Southeast Asia. Betel nut chewing, still largely unknown to Westerners, is a vice still awaiting introduction.

Portulacaceae

Portulaca oleracea L. (purslane, verdolaga), is a common, spontaneous weed found throughout the tropics and the warmer parts of the temperate zone. Its wide adaptation is due to its high genetic flexibility that rapidly permits adaptation to new environments. All the many forms are edible. Nevertheless, the more succulent, selected forms are often distinguished as variety *sativa*. The variety *giganthes* is a large and vigorous form sometimes grown as an ornamental. Other species are less attractive, while probably all species are edible in an emergency. The species is extremely weedy, and indeed depends on man to provide a suitable environment. It thrives in newly disturbed areas, and in cultivated fields. In more weedy areas it tends to die out by competition from other plants. Its highly succulent nature is maintained even under relatively dry conditions. It can withstand drought for long periods, and flourish after a slight rain. Of the 100 or more species, some are typically found only on beaches or salty flats. The related *Portulacaria afra* Jacq., sometimes known as elephant grass, is an upright succulent ornamental herb.

Purslane is a vigorous, succulent, prostrate annual herb with glabrous foliage, and with obovate to spatulate leaves (Fig. 25). The plant creeps, and carpets the soil by rooting at the nodes. The bright yellow flowers appear almost sessile in the axils of the leaves. They are up to 3 cm in diameter, especially in the ornamental forms. The fruit is a circumscissile capsule containing a large number of fine seeds. The leaves are dull green or tinged red with anthocyanin.

The leaves and tender shoots can be eaten raw and have a mild pleasant flavor. They are frequently used in salads. The leaves make a good food for chickens and for canaries. They are cooked as a spinach dish, mixed with rice or stew, or with cooked meat dishes.

Although tolerant of many soils including those with extreme conditions, purslane favors sands or sandy loams. Since it is seldom cultivated, cultural instructions are difficult to give. When improved forms are obtained through French catalogs, the ideal site would be fairly rich in nitrogen, but free from weed competition. The young plants grow slowly at first due to the limited size of their seeds, but once established grow very rapidly and yield a crop every 2 weeks. Purslanes are usually thought of as a nuisance in the garden for they grow so readily, re-root when cut and left in the field, and distribute many thousands of seed. Perhaps in the home garden the best solution is to eat them. Unfortunately, they are also highly attractive to various kinds of insects, which may be either a curse, or a blessing, depending on the viewpoint of the gardener.

In some soils purslane tends to accumulate excess nitrates and becomes poisonous to cattle. Purslane can also contain excessive amounts of oxalic acid, and thus should not be eaten regularly in large quantities.

Figure 25.—An edible *Portulaca* from the fields of Puerto Rico.

Solanaceae

The genus *Solanum* (nightshade), is a very large and varied one which includes both weedy and non-weedy species as well as a number of well known edible and ornamental cultivars. Plants are herbs, shrubs, or even small trees, and some climbers. As a group they are easily recognized from their flowers with a characteristic cone of 5 anthers on very short filaments. The foliage is often spiny. The ripe fruit, a berry, is frequently eaten. On the other hand, leaves and fruits of many species are poisonous due principally to the presence of glycoalkaloids. Sometimes these disappear as the fruit ripens. The glycoalkaloids, if produced in quantity, can serve as precursors for cortisone and steroidal drugs. Others are used directly in both primitive and modern medicinal practices. The commonly cultivated species with edible green leaves are mentioned elsewhere. Here the principal weedy and wild species bearing edible green leaves are briefly mentioned. These are sometimes cultivated sporadically.

S. nigrum L. is an extremely variable species occurring throughout the temperate and tropical zone. The berries are often edible (Moralle, Garden Huckleberry, Wonderberry, etc.). The unripe fruits and leaves are often said to be poisonous. Var. *guineense*, however, is grown for its leaves in West Africa. Plants are easily established from seed or cuttings. These weeds should not be eaten in quantity until the edible qualities of the available races are carefully established.

S. nodiflorum Jacq. (Lumbush) is sometimes regarded as a variety of *S. nigrum*. It is more upright and bushy than most forms of the latter. Both the young leaves and the fruits are eaten. Both are somewhat bitter. Whether it should be regarded as a weed or cultivated species is difficult to say.

S. macrocarpon L. is another species that might be more cultivated than wild. It is perennial, glabrous, and shrubby. Originally from Africa but widely introduced into Southeast Asia, this species produces a small fruit similar to the eggplant. The fruits may be eaten when very small, often raw, but in many places the plant is grown chiefly for its edible leaves.

Solanum aethiopicum L. (Mock tomato) is an African, herbaceous species, with glabrous edible leaves. The small red fruits are also eaten cooked.

Other species with edible leaves are listed in the index. It is highly probable that the leaves of many other species will prove edible when systematically tested. *Solanum* species should, however, be tested with much caution. The alkaloids are quite powerful, and in some cases eating of just a few leaves, cooked or not, can be disastrous.

In addition to the *Solanum* species, some weedy species of *Physalis* bear edible leaves. *Physalis* species are fairly well distributed in the tropics, especially of the Americas. They are distinguished from other members of the Solanaceae by the leafy bracts that enclose the fruit until maturity. Some bear edible fruit which is sometimes compared to the tomato, hence the name "husk tomato". One of the best of these is *P. peruviana* L., a pleasant fruit with a poor after taste. It has been introduced to Australia from South America, where it has been completely naturalized. The leaves are sometimes eaten. Another species with both edible fruits and leaves is *P. angulata* L., distributed throughout the tropics, but used as a source of edible leaves in Central Africa.

Among the weedy species of the family Solanaceae, the *Datura* species are the most poisonous, and their culture in the garden is not recommended.

Sterculiaceae

In the Sterculiaceae a number of wild species, mostly trees, are used as sources of edible leaves. Among the weedy species, the pantropical *Melochia corchorifolia* L. has a history of edible leaves, in India, for example. Another edible species of the East Indies is *M. umbellata* Stapt. Many species have highly pubescent leaves that are not really suitable when cooked. Leaves of the common West Indian annual *M. pyramidata* are said to be edible. Yet in Costa Rica the species is associated with paralysis and death of cattle.

Typhaceae

The familiar cattails of wet places of tropics and temperate zone are the sources of several kinds of food. The starchy tubers of most species are edible. The young inflorescence can be boiled as a vegetable. The young leaves or shoots are eaten, especially of *Typha angustifolia* L., a very widespread species. As in the case of many monocotyledons, the young leaves are first removed from the protective sheath of previous leaves while they are still tender, and before they have become very green.

Umbelliferae

Leaves of quite a number of species of the family Umbelliferae are edible. Nevertheless, poisonous species are common, and extreme caution should be taken on eating leaves of a new species. Celery (*Apium graveolens* L.) is frequently found wild in cooler parts of the tropics. The leaves are good raw or cooked, but may be strong-flavored. An equally edible Indian species is *A. sowa*. Among the more weedy edible species are *Eryngium foetidum* L., common and easy to identify, and its relatives. Several species of *Hydrocotyl* should also be mentioned. Species of this family tend to have highly flavored leaves and some are used primarily for seasoning such as parsley (*Petroselinum crispum* Hill.).

Urticaceae

Many of the nettles of both the temperate and tropical zones are edible. Their edible qualities can hardly be appreciated when one thinks of the itching sensation caused by the hairs of many species. The family consists chiefly of herbs and shrubs, but also includes a few small trees. A family with many weeds, it is known best for the cultivated *Boehmeria nivea* (L.) Gaud, the source of the fiber ramie. The young leaves of this species can be eaten.

The members of the family with edible young leaves are many. The genus *Urtica* is widely represented throughout the world. Young plants, shoots, and young leaves of the common weed *U. urens* are edible. The succulent and often attractive species of *Pilea* are often edible. *Fleurua aestuans* Gaud, a noxious weed in the coffee groves of Puerto Rico, is eaten as a leafy

vegetable in West Africa and Ceylon. The shrubby species with edible leaves include *Cudrania javanensis* Trecul. and *Laportea terminalis* Wight. Even the genus *Urera* that includes some of the most painful and ugliest of the nettles, includes edible species. A list appears in the appendix but probably many less common weeds of the family bear edible leaves.

One of the most undesirable weeds of waste places that persists and even thrives in difficult locations where few other plants will grow, and where human, animal, and vehicular traffic beat it to the ground is the puncture weed, *Tribulus terrestris* L. (Zygophyllaceae). The plant is characterized by its sprawling tendency, its short pinnately compound leaves, small but attractive yellow flowers, and especially by its capsule characterized by several sharp, straight spines that can puncture a shoe or a bicycle tire. It is a species often found in sandy areas, but by no means confined to such. It resists attempts to eradicate it, for the seeds can persist for long times in the soil, and germinate irregularly. Several related species are known in the tropics.

Although often said to be poisonous (see later), the leaves and tender shoots are eaten in India and East Africa. The authors have eaten the leaves of the related *T. cistoides* L., and have seen the flowers of another species eaten by iguanas in the West Indies. Without doubt, however, this particular plant should never be planted for its edible leaves.

Species of the related genus *Fagonia* are used for their leaves in the Sahara desert.

Other Weeds

In a survey of the weeds of Puerto Rico (the home of the authors) of which the leaves are already described as edible, 27 species were found (Table 6). In addition, 55 weedy species were related to species previously described as bearing edible leaves. No doubt the leaves of many of these species are equally edible, but in a few cases, such as the *Solanum* species, it might be somewhat risky to make the test. This brief survey is suggestive, however, of the richness of edible leaves that should occur in almost any tropical area.

TABLE 6.—Edible weeds of Puerto Rico or weeds that have edible relatives

Family	Species	Edibility
Acanthaceae	*Thunbergia fragrans*	Unknown
	T. alata	Edible
Amaranthaceae	*Achyranthis indice*	Unknown
	Amaranthus dubious	Edible
	A. spinosus	Edible
Asclepiadaceae	*Asclepias nivea*	Unknown
Batidaceae	*Batis maritima*	Edible
Begoniaceae	*Begonia decandra*	Unknown
Boraginaceae	*Cordia corymbosa*	Unknown
	Tournifortia hirsutissima	Unknown
Bromeliaceae	*Bromelia pinguin*	Edible
Capparidaceae	*Cleome spinosa*	Unknown
Chenopodiaceae	*Chenopodium ambrosiodes*	Edible
Compositae	*Artemisia absinthium*	Unknown
	Bidens pilosa	Edible
	Centaurea syanus	Unknown
	Daucus carota	Edible
	Emilia sonchifolia	Edible
	Lactuca intybacea	Edible
	Pluchia odorata	Unknown
Compositae	*Synedrella nodiflora*	Edible
	Vernonia cinerea	Edible
	V. sericea	Unknown
Convolvulaceae	*Calonyction aculeatum*	Edible
	Ipomoea pes-caprae	Edible
	Ipomoea tiliaceae	Unknown
	Jacquemontia pentantha	Unknown
	Quamoclit pinnata	Edible
Cruciferae	*Brassica campestris*	Edible
	B. nigra	Edible
	Lepidium virginicum	Unknown
Euphorbiaceae	*Croton lobatus*	Unknown
	Jatropha curcas	Edible
	Poinsettia heterophylla	Unknown
Graminae	*Bambusa vulgaris*	Edible
	Echinochloa colonum	Edible
	Eleusine indica	Edible
	Setaria geniculata	Unknown
Geraniaceae	*Impatiens balsamifer*	Edible
Labiatae	*Hyptis atrorubens*	Unknown
	H. pectinata Port	Edible

TABLE 6.—Continued

Family	Species	Edibility
Labiatae	*Salvia serotina*	Unknown
	Ocimum sanctum	Edible
Leguminosae	*Abrus praecatorius*	Edible
	Clitoria ternata	Edible
	Crotalaria retusa	Edible
	C. striata	Unknown
	Ditrimexa occidentalis	Edible
	Herpetia alata	Edible
	Phaseolus adenanthes	Unknown
	Vigna repens	Unknown
Liliaceae	*Aloe vulgaris*	Unknown
	Smilax coriaceae	Unknown
Malvaceae	*Sida carpinifolia*	Unknown
	Urena species	Edible
Nyctaginaceae	*Pisonea aculeata*	Unknown
Papaveraceae	*Argemone mexicana*	Edible
Plantaginaceae	*Plantago major*	Edible
Pontederiaceae	*Eichornia crassipes*	Edible
Polygonaceae	*Polygonum portorricensis*	Unknown
Portulacaceae	*Portulaca oleraceae*	Edible
Rosaceae	*Rubus rosaefolius*	Edible
Rubiaceae	*Randia mitis*	Unknown
Solanaceae	*Physalis angulata*	Edible
	Solanum citratum	Unknown
	S. torvum	Unknown
Sterculiaceae	*Melochia pyramidata*	Edible
	M. tomentosa	Unknown
	M. villosa	Unknown
Typhaceae	*Typha angustifolia*	Edible
	T. fruticosa	Unknown
Umbelliferae	*Eryngium foetidum*	Edible
	Hydrocotyl umbellata	Unknown
Urticaceae	*Urera baccifera*	Unknown
	Fleurya aestuans	Edible
Verbenaceae	*Stachytarpheta jamaicensis*	Edible
	Lantana camara	Edible
	Lippia nodiflora	Edible
Zingiberaceae	*Zingiber zerumbet*	Unknown
Zygophyllaceae	*Tribulus cestoides*	Edible
	Kallstroemia maxima	Unknown

CHAPTER V

Tropical Trees With Edible Green Leaves

The deep emotions inspired in mankind by trees possibly result from the many ways trees are put to use or serve him. From trees the physical necessities of life are taken: wood for shelter and for cooking, bark and fiber to be pounded or to be woven into cloth, both sweet and starchy fruits, nuts, and rich sources of edible oils, liquids (not common) to be used as beverages with or without fermentation, or to be evaporated to yield sugar. In addition, trees fill aesthetic needs. They are often graceful and pleasing to the eye or give a sense of permanence by their sheer size. They often outlive humans, and in fact, because they frequently grow so slowly, it is often said that one must have faith to plant trees.

In spite of their abundance and their multiplicity of uses, trees are seldom thought of as sources of edible green leaves. In fact, very few trees of the temperate zone are utilized in that fashion. In some areas of the tropics, however, the edible qualities of the leaves of certain trees are much appreciated. It is common, for example, to see the gnarled living fence posts of various species that are so shaped because their leaves are continually removed for animal fodder. The harvesting of the edible crop maintains the form of the hedge. Some type of pruning of trees bearing edible leaves is always desirable, for otherwise the leaves are often out of reach and difficult to obtain.

Among the families of flowering plants perhaps the most important with respect to trees with edible leaves are the Leguminosae and the Euphorbiaceae. Both families, but especially the former, are sources of important and minor edible crop plants. However, both families also contain species with deadly poisons. Often enough, parts of a poisonous species are sometimes perfectly edible if properly prepared.

Leguminosae

Trees of the Leguminosae are well known, widely distributed, and probably available to almost anyone in the tropics. A description follows of some of the most important species with edible leaves.

The 65 or more species of *Erythrina* (Coral trees) are widely distributed around the world, for they originated in America, Asia, or Australia. The trees are known for their beauty, often of form but almost always of flowers. These are bright orange or red, and normally occur in upright clusters. In some cases flowering before leafing creates a spectacular effect. Some of the smaller species can be successfully grown in pots. In most cases small birds seeking nectar pollinate the flowers.

The Erythrinas are very common trees in the tropics. They are usually propagated from seed, but some species can be grown from large, woody cuttings. These make colorful and long-lasting fence posts. Both large and dwarf trees are often used for shade in plantings of coffee, bananas, vanilla, and black pepper. Many of the species are prickly. Few are useful for timber, but many uses have been recorded in folk medicine.

The leaves of coral trees are commonly used for fodder. It is not uncommon to see people harvesting the leaves along the fence rows in the tropics, often as not to feed them to rabbits. However, other animals eat the leaves also, and can keep the lower trunks of the trees pruned clean. The dwarf bucare, *E. berteroana* Urban (Fig. 26) is one of the easiest species to grow, and thus is often used to form retaining walls or hedges. The leaves are most commonly eaten cooked in stews with other foods, but it is not unusual for them to be eaten raw. A few of the edible species, their sources and uses, are listed below. Other species with edible leaves are listed in the appendix, and without doubt other species remain to be tested.

E. berteroana Urban.	Central America	Buds, young leaves, young twigs, cooked
E. fusca L.	S. E. Asia	Young leaves boiled or raw
E. indica L.	Ceylon, India	Young leaves in curries
E. poeppigiana Walp. (O. F. Cook)	South America	Flowers in soups and salads
E. variegata L.	Indonesia	Cooked, in salads

In contrast, the orange or red seeds are poisonous. They contain the alkaloid hypophorine, which acts on the nervous system. Browsing animals are frequently killed from eating the seeds. Nevertheless, the seeds are often used in necklaces, and are sometimes made palatable by cooking, a risky practice. When pounded, the seeds of *E. variegata* are used as poultices for snake bites, and even for cancer.

Gliricidia sepium (Jacq.) Steud. often known as mother-of-cacao, is a small deciduous tree from tropical America commonly planted in fence rows or hedges (Fig. 27). In dry areas, it is used as a windbreak, and because it flowers fast as new leaves are produced, it is sometimes used as an ornamental tree. Mother-of-cacao grows rapidly either from seed or from readily-rooted cuttings. Fence posts take root and then last for many years. Mother-of-cacao is often used as a shade tree, not only for cacao, but also for vanilla and coffee. The tree fixes nitrogen efficiently, and thus serves also to fertilize the nursed crop. Because of its open structure and small size, this species does not compete so much with the shaded crop as do some other species.

The roots, bark, seeds and perhaps even the leaves are toxic, and are used in home medicines and poisons. The poisonous qualities of the leaves are questionable. While recognized as nutritious for cattle, the leaves are said to poison horses and dogs. It is difficult to get an exact statement from the literature as to the effects of leaves on humans, but presumably they are edible, and are appreciated in some parts of the tropics. This is an important question that must be resolved before the leaves are eaten in quantity. It is quite possible that cooking removes or inactivates the poisonous alkaloid. The colorful flowers are also eaten, fried or boiled.

The genus *Cassia* (Senna) comprises about 600 species of herbs, shrubs, and trees throughout the tropical, but also extending into temperate zones. Many of the species are of ornamental value. Among these are the lovely Rainbow Shower trees of Hawaii (*Cassia* hybrids), the well known Golden Shower (*Cassia fistula* L.), other yellow flowered species, and many others.

Figure 26.—Edible leaves and ripe pods of *Erythrina berteroana*, dwarf bucare.

Figure 27.—The leaves of mother-of-cacao, *Gliricidium sepium*.

A few species yield substances of more commercial value. The leaves and pods of several species (*C. angustifolia* Vahl., and *C. senna* L.) are dried and marketed as senna, a mild laxative. The purgative action is caused by emodin and other glucosides. From *C. auriculata* L. the bark is used in tanning. Several species are useful as green manure crops. The seeds of *C. occidentalis* L. are sometimes roasted as a coffee substitute. This is a species of American origin. Finally, leaves of the beautiful ornamental *C. alata* L., already discussed, are used in the treatment of ringworm.

When the glucoside content of the leaves is not too high, the leaves of various *Cassia* species are edible. A list of the principal species used as a source of green leaves is given in the appendix. The leaves of *Cassia* species should always be eaten with caution, and judicious experimentation should be undertaken before the leaves of any tree are accepted as safe. A tea of some of the species is a strong purgative. Cooking removes some of the glucosides. In spite of their purgative qualities, the leaves of even the more medicinal species are often cooked in small quantities with other dishes. They are considered a tonic, and without doubt exert a regulating influence.

One tropical herbaceous species, *C. tora* L., is probably a more reliable source of edible leaves. The foliage is somewhat ill-smelling, but this disappears on cooking. Only the youngest leaves are used. The leaves of *C. siamea* are poisonous, reportedly due to an alkaloid. This weedy tree should be recognized and its leaves avoided.

Sesbania grandiflora Pers. (agati, báculo) is a small, upright, and rapidly growing tree from Malaysia and India. It is widespread throughout the tropics, where it is appreciated for its exceptionally large flowers, usually white, but red in some varieties. Unfortunately, their smell is unpleasant. The tree begins to flower at only 2 years of age, when it is still small. Other noteworthy characteristics of the tree include that it has finely pinnate leaves and a long, narrow seed pod, with small seeds separated by ingrowths of the pod walls. In contrast to many other trees, this species is well adapted to both dry and moist regions.

The tree has many minor uses. Its wood is soft and white, but seldom used. The living tree is used as a nurse or shade tree, particularly for black pepper. The bark is bitter and is used medicinally, as an emetic, and in lesser doses, for treatment of stomach disorders. The tree is grown sometimes for its value as a green manure crop, and more often as a source of green leaves for cattle. It is sometimes planted in pastures for this purpose.

The flowering shoot, flowers, pods, and young leaves are all used as greens. The flowers are often bitter, and are not appetizing to many people. The most common way of eating is in stews or salads, but the leaves may also be used as a spinach.

The utilization of leaves is widespread, from Africa to India, Indonesia, and some of the islands of the Pacific. At least two other species of *Sesbania* are used as sources of edible leaves (see appendix). Nevertheless, the young pods and the flowers are more appreciated as food than the leaves.

One of the most annoying of weedy trees throughout the tropics, but particularly obnoxious in dry regions with well-drained soils is *Leucaena leucocephala* De Wit. (zarcilla, tintan, lead tree). The tree grows very rapidly from seed, is very aggressive, blooms at a very young stage (Fig. 28), and pro-

Figure 28.—The pinnate leaves of the weedy tree *Leucaena leucocephala.*

duces large quantities of seeds. The seeds germinate irregularly so that it is very difficult to eliminate the species from a garden. Cut trees regrow rapidly and soon dominate other cultivated or wild plants. Areas where the tree is particularly prevalent include the Hawaiian and Virgin Islands. Its origin, however, is the New World.

In spite of its weedy nature, this species is often planted for a variety of other purposes. It can be used as a source of charcoal, in which the plantings are recut each 6-7 years. As in the case of other legumes, it replenishes the nitrogen of exhausted tropical soils. It serves as a shade crop and a hedge plant.

Although often used as a forage plant, the foliage contains a harmful alkaloid, mimosine, which causes horses and donkeys to lose their hair. It is often fatal also to rabbits and pigs. Sheep, goats, and cattle were considered immune to the poison. Now it is known that it can adversely affect cattle when the diet contains excessive quantities. The substance is concentrated in the young leaves as well as the seeds. Some breeding work to produce less toxic varieties for forage is underway.

The shiny brown seeds are rather attractive and thus are often used in necklaces. They must be first softened by boiling. The full grown but unripened seeds are dried and eaten uncooked. Seeds are ground into a coffee substitute in the Philippine Islands. Ripe seeds are also eaten parched. Habitual consumption results in loss of hair.

As a food for humans, the young pods are most commonly used. The tender leafy shoots too are occasionally used in stews. The flowers are less commonly eaten with rice.

The genus *Bauhinia*, of almost 200 species from the tropics of both hemispheres, is best known for its attractive trees and woody vines that bear large open flowers with a striking superficial resemblance to orchids. From this has come the name "Poor man's orchid". The leaves of many consist of two roundish lobes or partially joined leaflets resembling a cloven hoof, hence the name "pata de vaca" (cow's foot). A number of species are prized for their flowers, including *B. variegata* L., *B. purpurea* L., *B. pauletia* pers, *B. petiolata* (Mutis) triana, and *B. monandra*. Colors of the flowers range from pure white through delicate rose and lavender, to dark reds and purples. Usually long, flat pods are borne in profusion, and the rather large and attractive seeds are sometimes used in necklaces.

As a group, the *Bauhinia* species have minor medicinal uses, or are occasionally used for fibers for rope, and in some cases, as very good sources of tannins for preparing leather. A few of the larger species yield wood used in agricultural implements.

Many of the species are partially sterile. Among these, the Hong Kong *Bauhinia* is believed to be the most beautiful, with large, spectacular flowers. Experimental hybrids have been produced, and thus the beauty of these species may be enhanced by judicious breeding.

The leaves, flower buds, flowers, young shoots, and young pods of some species are often eaten as vegetables. The flower buds are sometimes pickled. The young cooked leaves are sour in taste, or have unusual flavors and are used as condiments. Probably leaves of all of the species are edible at least as animal feed. Among the species used for human consumption are

the common ornamentals *B. variegata* L. and *B. purpurea* L. Other species with edible leaves are listed in the appendix. In contrast to legumes of other genera, none of the *Bauhinia* species are known to be poisonous.

Trees of the genus *Pterocarpus* are found in both old and new worlds, and have been widely introduced as handsome shade trees. Many are good sources of timber, and others are valuable for their tannins and dyes. The pods of these species are distinctive in that they are flat, often discoidal, and contain a single seed.

Young leaves, flower buds, and flowers of a number of species are frequently eaten as vegetables. The edible species include the common roadside tree *P. indicus* Willd., a source of a valuable reddish timber, and *P. angolensis* D.C., known throughout Central Africa. The fruits and the leaves as well of *P. santalinoides* Léther ex D.C., are roasted and eaten in times of scarcity. Several other species are also utilized, and still others remain to be tested.

Before leaving the Leguminosae, a few other genera, the trees of which yield edible green leaves, should be mentioned. These include *Acacia*, *Afzelia*, *Albizzia*, *Ceratonia*, *Cynometra*, *Delonix*, *Parkia*, and *Pithecellobium*. A few species that also bear edible fruits were mentioned in an earlier chapter.

Euphorbiaceae

In spite of its size (8000 species) and diversity (herbs, shrubs, and trees) the family Euphorbiaceae is not an important source of edible plants. Many of its species are, in fact, poisonous, and a certain amount of caution is therefore appropriate in dealing with plants of this family. The species are well scattered through the tropics and the temperate zone, and some examples are probably known to everyone. Some of the economic species with edible leaves (*Manihot*, *Acalypha*, *Ricinus*, *Codiaeum*, and *Euphorbia pulcherrima*) have been previously mentioned. Here only the trees will be treated, and most of these are not very common.

The genus *Bridelia* is represented by trees, shrubs, and a few vines found throughout the tropics. They are little known in most areas and have few economic uses, except in tanning and folk medicine. *B. micrantha* (Hochst.) Baill. is known for its edible fruit in Central Africa. *Bridelia scleroneura* Mill. Arg. is known chiefly in the Congo of Africa, where it is used as a source of leaves. One wonders how many more species of this genus might be equally edible.

The genus *Claoxylon* is less well known for it occurs only from Madagascar to the islands of the Pacific. Several different species are used as vegetable or condiments in one form or another. The young branches of *C. longifolium* Miq., a small tree, are sold in the markets from Malaysia to the Pacific as a fresh vegetable. The leaves of *C. polot* Merr are purgative in nature, but nevertheless used as a condiment in sauces in Indonesia. One species is more generally distributed throughout the Congo. *C. oleraceum* O. Prain. It is well known in its particular habitat as a source of edible green leaves.

The genus *Glochidion* is rather small, and of Asiatic origin. These trees are little known outside of their native habitat, and have little value except for tannins, and cheap lumber. Several bear attractive flowers but have seldom been introduced from their native habitats. Several species serve as

sources of edible leaves, including *G. borneense* Boerl. Only the youngest leaves of *G. rubrum* Blume, a shrub, are eaten. The others contain too much tannin. Another tree, *G. blancoi* Lowe is valued for its young leaves and shoots in the Philippine Islands.

Among the even less known edible leaved plants of the Euphorbiaceae are species of the genera *Hymenocardia*, *Maesobotrya*, *Microdemus*, *Pterococcus*, and still others (see appendix). These include not only trees but shrubs and woody vines.

Other Families

Many families of trees, even some large ones, do not include species with edible leaves. Often the trees that are edible are not only little known, but are also poorly distributed, or unknown outside of their native regions. The task of introduction is thus still unfinished, and without doubt many trees remain to be introduced and made known to the world of horticulture. Some of the more interesting are included here.

Two species of the family Bombacaceae, a small family of large trees, are widely utilized for a diverse number of products. One of these, *Adansonia digitata* L. (baobab) is a large tree with enormous trunk characteristic of the savannahs of Africa. The seeds do not germinate very well, and young trees are seldom seen. Thus, in some areas the trees are believed by local people to have originated at their present size. In pot culture in the greenhouse some germination of carefully tended seeds is seen after 1 year.

Many parts of the baobab tree find a special use. The short, wide trunk is composed of a soft wood of no value for timber, but useful as wood pulp. The inner bark is fibrous, and has been used for ropes; the bark is pounded into a soft, white paper, or a fabric used for mats. The flower is large and exquisite (Fig. 29), but sometimes not seen among the mass of foliage. The fruit hangs from a long stem and has been responsible for the name, the dead rat tree. The pulp around the seeds consists chiefly of tartaric and citric acid. It is eaten fresh, sometimes cooked into a porridge, or made into a drink. The seeds are acid, and are sucked on. When cooked they taste like almonds, and contain about 12 percent oil. The seeds are also dried, ground, and used as a substitute for coffee, or as a meal in times of scarcity. The tender roots of the tree are used as a stewed vegetable. The pollen is made into glue.

The leaf of the baobab is palmately divided into 5 to 7 segments, and may be downy or smooth. The young leaves and shoots serve as cooked greens, in soups, and as a condiment with other foods. The leaves, or tea made from them, are considered useful in reducing perspiration. Both fresh and dried leaves are commonly marketed. Leaves are obtained by continuously lopping off the new branches from smooth-leaved trees grown especially for this purpose. Downy-leaved trees are allowed to grow for fruit production and other uses.

The second economically important species of the Bombacaceae is the ceiba (*C. pentandra* L., the silk-cotton tree). It is a tree widespread throughout the tropics, and well known for its large trunk, flaring buttresses, height of up to 100 feet, and large horizontal branches. The tree grows best in forest conditions with heavy rainfall, generally at low elevations.

Figure 29.—The flower and fruit of *Adansonia digitata*, baobab.

The kapok of commerce comes from this species. It is the floss derived from the wall of the large seed capsule. The chief uses for this material are associated with its bouyancy and insulating properties. It can also be spun into thread and woven into cloth. Ceiba is an important plantation crop tree.

Other uses are also common. The soft wood, for example, is used for dugout canoes. Cuttings are used as living fence posts. The buttresses are cut up for doors, tables, etc. Very young, unripe pods are cooked as a vegetable in Indonesia. The seeds are also edible either fresh, germinated, or after pressing the oil, are used as a cattle feed.

The leaves also have many uses, for example, in a hair lotion and as medicine for coughs. The young leaves are cooked as a vegetable. They may also be dried for later cookery. The leaves of young trees are eaten by cattle.

The fig of temperate and subtropical regions is only one example of a very large and diversified genus (*Ficus*, family Moraceae) of shrubs and trees that occurs throughout the tropics. Some figs are especially noted for their aerial roots which grow into new trunks, and account for the spreading tendency of the banyans. In other species, however, the roots serve chiefly as props for the long branches. Most species produce abundant latex which has been used as bird lime (a sticky substance placed on branches to catch birds), and as inferior rubber.

The fruits of many figs are edible although none match in quality those of *F. carica* L., the fig of commerce. Some figs have very bad odors, but the fruits can be eaten if cooked green. There are about 20 species with edible fruits.

The leaves of figs are not only frequently used as food, but are also smoked, along with opium, or chewed with betel nut. Young stem tips of *F. alba* Reina are used in salads in Indonesia. The leaves of this species are also used as horse feed. This is a rapidly growing shrubby species of possible ornamental value. The large leaves of *F. benghalensis* L. are used as platters, and also as elephant feed. Very young leaves of the rubber tree, *F. elastica* Roxb. are eaten in salads. The leaves of at least a dozen other Asian species are edible, and at least five African species bear edible leaves (see appendix).

The family Gnetaceae is a strange source indeed for trees with edible leaves. The principal genus *Gnetum* contains about 30 species, most of Southeast Asia. The trees and woody vines bear small fruits that are single seeded, and somewhat fleshy. The fruits are sometimes sweet and edible, or in other species the starchy nuts themselves are eaten. The seeds of some species are covered with irritating spicules. Some of the species are occasionally cultivated, and merit more attention as a source of nuts.

Best known of the species is *G. gnemon* L. The attractive tree reaches a height of about 30 feet. The leaves are opposite, dark green, and shiny.

The red fruits of about 2.5 cm long, and occurring in clusters, are eaten raw but they are tough. The seeds are eaten roasted, boiled or fried. The leaves are not used everywhere where the tree is grown, but in some regions they constitute a much prized and nutritive spinach dish. The young flowers and fruits are also eaten. All require cooking to eliminate their irritating substances.

The little known family Salvadoracea contains one species of merit, *Salvadora persica* L., known also as toothbrush tree, and the mustard tree (as

referred to in the Bible). Although completely unrelated to the Cruciferae, this tree found from West to East Africa, is appreciated for the pungent odor of its leaves. The leaves are eaten raw in salads, and as antidotes against poison. The berries are small and red, and though sweet, are also pungent. They are dried in the form of raisins, and are thus marketed.

Quisqualis indica L., the rangoon creeper, is a fairly well known and distributed shrub of the Combretaceae, appreciated for its showy and fragrant flowers. As in the case of others of the genus, it is a plant of the Old World tropics. Several related species are used for medicinal purposes. In the cases of this species, the fruits are dried and sold medicinally in Indonesia. They are dangerous, however, and can cause unconsciousness and even death. The fresh fruits are used as a vermifuge when half ripe. The leaves are used in a variety of ways, as a lotion for boils and a potent brew for headaches. It is the young leaves and stems, however, that are eaten, principally in Indonesia, as either a raw or steamed vegetable. The proper stage to gather them is before the bronzing associated with anthocyanins in the young leaves disappears.

Pisonia alba Span., from the Nyctaginaceae, is sometimes called tree lettuce. It is a common tree in India and Indonesia, growing wild but also cultivated in gardens. The leaves of the female tree are bright yellow green, and are favored over the darker leaves of the male as a food. Since the trees are propagated by cuttings, the male is seldom seen. The leaves are eaten with rice or boiled as spinach. Other species of *Pisonia* are common in the tropics but some have strong emetic properties and should be avoided. All *Pisonia* species are fast growing trees with soft wood. The base of the tree is often enlarged grotesquely.

Morinda citrifolia L. (Rubiaceae) is a small tree (Fig. 30) grown widely throughout the tropics, which does especially well in dry, well-drained areas, including almost barren lava rock of volcanic islands. A few variegated leaf forms are used for ornament. It is also notable for its large, elliptic shiny leaves. Known as the noni (in Hawaii) or Indian mulberry, the white fruit has a very unpleasant odor when ripe, and is used as a famine food. The Burmese cook the young fruits for curries, or it is eaten raw. A common source of folk medicines, it also yields dyes, timber, and affords shade for coffee and support for pepper. The older leaves are used as wrappers but the young are cooked as a vegetable.

The neem or margos tree, *Azadiracta indica* A. Juss. (Meliaceae) is common wild and cultivated in India, where it is prized for its many uses. In addition it is now widely distributed in West Africa. It produces timber, oil used in lamps from the seed, medicinal bark from the trunk and roots, a sweet sap used for toddy, and leaves for insecticidal purposes and for fodder. The somewhat bitter leaves and flowers are added to cooked foods as flavoring, and for their supposed value as tonic. The young leaves contain 11.6 percent protein.

The neem tree should not be confused with the Chinaberry tree, *Melia azedarach* L., all parts of which can cause human and animal poisoning.

Moringa oleifera Lam. (horseradish tree, resedá, Moringaceae) is a small tree (Fig. 31) introduced to all parts of the tropics from eastern India, and very widely grown not only for its edible parts but also as an ornamental. The tree has the potential to flower throughout the entire year. The family is small, little known, and yet distinctive. Several other species are useful includ-

Figure 30.—Leaves and fruit of *Morinda citrifolia.*

Figure 31.–Mature trees of *Moringa oleifera*, the horseradish tree.

ing *M. peregrina* (Forsk.) Fiori, known in West Africa and used there as a condiment, and for other purposes.

The tree seldom reaches 25 feet in height. It is characterized by a corky bark that yields a gum of some minor value. Foliage is feathery or fernlike due to the finely tripinnate division of the leaves. The white flowers are borne in abundance, are quite showy, and are attractive to bees. The seed capsules are up to 45 cm long, triangular in cross section and split into three parts at maturity. The seeds have broad, fine, membranous wings. Some varieties which flower profusely are used chiefly for the young fruits, whereas others yield principally leaves.

Almost all parts of the plant are useful as food, but always cooked. The seeds yield a fine oil which is edible. The young plants from seeds are very tender and make an excellent cooked green vegetable. The shoot tips, leaves and flowers make excellent spinach. The young pods have a flavor reminiscent of asparagus. The thick soft roots have a strong flavor of horseradish due to an alkaloid. When peeled, dried, ground, and blended with vinegar they substitute for this condiment.

Moringa is especially adapted to low elevations and to dry areas, and may resist several months of drought. It needs a well-drained soil. Propagation is usually by seeds, but cuttings may also be used. Plants are best started in areas where they will be used, and can be seeded heavily (every few inches) and thinned later to suitable distance. The mature tree can obtain a trunk diameter of 25 cm, but would be of little use at that size. A better system is to maintain the trees as a hedge, with plants about 3 feet apart. The hedge should be trimmed regularly not only to maintain its shape but also to provide the crop of edible leaves. Mulching and fertilizing will improve the production and quality of the leaves.

The trees of *Moringa* are especially susceptible to termites, and in some areas their culture may be limited. The wood is soft, but useful for paper. The tree is weak, and limbs are easily broken.

Medicinally the pulp of the root (or other parts) is used as a counter irritant similar to "mustard plaster". In fact, many folk uses have been recorded.

To residents of both temperate and tropical regions, palm trees are considered precious. They are usually attractive, often beautiful, and sometimes romantic. Thus it seems a travesty to destroy them, particularly in order to eat only a small portion. Nevertheless, the young growing terminal bud of many species is often used as a vegetable. Under the names "palm cabbage" or "millionaires salad" this vital plant part is frequently served.

The number of palm species from which a suitable cabbage is taken is probably large. No one has systematically collected all the names of the edible species. Nevertheless, not all palms bear suitable cabbages. In some, removal of the cabbage is too difficult to justify the labor. In other species the flavor is not satisfactory.

The cabbage is removed by cutting the palm if necessary, removing the fronds, and then opening the trunk with axe or machete. The edible part consists of the bases of the young developing fronds tightly enfolded one in another. The color is usually white. In Brazil, where the destruction of palms is often necessary to open new lands for agricultural purposes, the canning of

the terminal bud is practiced on a commercial scale. Plantations of coconut palms have been established just to supply "cabbage."

The cabbage of the palm resembles cabbage of commerce (*Brassica oleraceae* L. var. *capitata*) only in having numerous thin layers of tissue. These are easily sliced finely to form a typical "slaw", which is flavored with oil, vinegar, or other substances, as it has little flavor of its own. The cabbage may also be cut into thick chunks or slices, and cooked as a vegetable.

The chief palms used for cabbages are those palmitos of the genera *Irearta* and *Geonoma* of South America, the palmitos of North America, in Brazil the species *Euterpe oleracea* Hart and *Acrocomia sclerocarpa* Mart., in the Caribbean, species of *Roystonea*, and *Oreodoxa*, in Africa *Borassus* sp., and at the time of elimination of old trees, the oil palm *Elaeis guineensis*. In Southeast Asia many species are used. The most ubiquitous species is of course the coconut, and it is well known as one of the better sources of cabbage in all the regions in which it is grown.

The young, unfolding leaves of a few species of palm are also used as green vegetables. In Southeast Asia, for example, the fronds of *Arenga* (Sugar palms) are so used. This method, which might be applicable to other species, avoids the destruction of the tree for its cabbage.

A full review of edibility of palm leaves would be desirable. In the appendix a list of species reported to have edible cabbages is given.

CHAPTER VI

Tropical Leaves as Spices and Teas

In addition to their uses in salads, stews, and side dishes, leaves have a wide variety of uses that can classify them as spices. Since leaves are being considered here chiefly for their edible value, no great attention will be placed on the fact that spices, including leaves were used for many centuries for other purposes. These included their use as incenses, as medicines, as cosmetics, as antidotes to poison, as perfumes, as aphrodisiacs and as preservatives for embalming. However since not all substances used for such purposes are spices, it follows that the word spice should be used for still a smaller group of substances. Perhaps the word "spicy" is the clue, for it suggests aroma, or pungency, a sharp but pleasant taste. But some leaves used as spices do not add exactly that to the food with which they are used. Let us define spice as a plant substance that is not eaten primarily as a food itself, but that is used to change the taste of food.

It follows that spices come from many parts of the plant, from leaves, stems, roots, bark, flower buds, seeds, etc. Distinctions between spices, herbs, and condiments can be forgotten here, for they are somewhat artificial. What is of interest is that many leaves of the tropics are used to flavor food. Nevertheless, the chief spices of the tropics are not from leaves, but from other plant parts such as in the case of pepper, cloves, ginger, cinnamon, allspice, vanilla, chili peppers, cardamom, nutmeg, and mace. From the temperate zones have come the principal leaves used for spices: basil, bay leaf, chervil, chives, savory, marjoram, oregano, mint, parsley, rosemary, tarragon, sage, and thyme.

For every well-known spice in the western kitchen there must be dozens of spices that are not well known but that are used somewhere throughout the tropics. In the appendix of edible leaves no attempt has been made to gather together the names of all the spices of tropical plants the leaves of which are used to flavor foods. For the most part, these "poor mans' spices have never been recorded in the botanical literature. From Burkill's treatment of the useful plants of the Malay Peninsula (1935) a partial list of the many species has been assembled (Table 7). This list does not include other species mentioned in this chapter.

Perhaps it is the ease with which mankind is bored that has led to the use of spices. The staple but bland dish, rice, so common throughout the tropics, is frequently made more savory by the inclusion of a few leaves. Each area of the tropics is characterized by special leaves used for seasoning. On the other hand, an important use for spices in the past has been to mask the flavor of spoiled food. Stomachs and consequently tastes had to be stronger in those days. As the need for hiding spoilage has lessened, so has the need for spices.

Many of the plants used as a source of edible leaves belong either to the Umbelliferae (the family of the carrot) or the Labiatae (the family of the mint). These two families merit special mention. A family of secondary importance is the Compositae.

Umbelliferae

This family, widespread throughout the temperate zone and not uncommon in the tropics, is characterized by flower clusters in the forms of an umbel. In addition to species used as a source of edible leaves (see appendix), the family is also the source of a number of spices so common that they are known in almost every household. However, many species bear poisonous leaves. The spices of this family are not tropical in nature. Nevertheless, they are frequently grown in the tropics where they sometimes prove sufficiently adapted to yield a worthwhile crop.

Coriander or culantro, *Coriandrum sativum* L., is grown chiefly for its edible seeds, the spice of commerce. It is a very old spice, recorded from the time before Christ and used in perfume, liquor, medicine, and aphrodisiacs. It is widely grown throughout the highlands of the tropics, where in some cases it has become a spice of commerce. The false coriander of Puerto Rico, *Eryngium foetidum* L., is used in form of the leaf (Fig. 32).

Table 7.—A list of plants of Southeast Asia, the leaves of which are used as condiments*

Scientific name	Common name	Family
Acacia farnesiana Willd.	Cassie flower	Leguminosae
Acronychia laurifolia Blume	Ketiak	Rutaceae
Aegle marmelos Correa	Baelfruit	Rutaceae
Allium odorum L.	Chinese chives	Liliaceae
Ancistrocladus extensus Wall.	Ox-tongue	Dipterocarpaceae
Antidesma ghaesembilla Gaert.	Sekinchak	Euphorbiaceae
Begonia tuberosa Lam.	Tuberous begonia	Begoniaceae
Claoxylon polot Mer.	Rock blumea	Euphorbiaceae
Coleus tuberosus Benth.	African potato	Labiatae
Crypteronia paniculata Blume	Sempoh	Lythraceae
Curcuma domestica Valeton	Tumeric	Zingiberaceae
Cymbopogon citratus Stapf.	Lemon Grass	Graminae
Cyrtandra decurrens de Vriese	Sorrel flavor	Graminae
C. pendula Blume	Rock sorrel	Graminae
Dendrobium salaccense Lindl.	Cooking orchid	Orchidaceae
Derris heptaphylla merr.	Seven finger	Leguminosae
Elettariopsis sumatrana Valeton	Fragrant gingerwort	Zingiberaceae
Eugenia polyantha Wight	White kelat	Myrtaceae

Scientific name	Common name	Family
Evodia roxburghiana Benth.	Sour-relish wood	Rutaceae
Gynura procumbens M.	Akar	Compositae
Homalomena griffithii Hook f.	Itch grass	Araceae
Hornstedtia sps.	Tepus	Zingiberaceae
Horsfieldia sylvestris Warb.	Pendarahan	Myristicaceae
Kaempferia galanga L.	Chekur	Zingiberaceae
Kaempferia rotunda L.	Kenchur	Zingiberaceae
Leucas lavandulifolia Smith	Ketumbak	Labiatae
L. zeylanica R. Br.	Ketumbak	Labiatae
Limnophila aromatica Merr.	Swamp leaf	Scrophulariaceae
L. villosa Blume	Swamp leaf	Scrophulariaceae
L. conferta Benth.	Swamp leaf	Scrophulariaceae
L. pulcherrima Hook. F.	Swamp leaf	Scrophulariaceae
L. rugosa Merr.	Swamp leaf	Scrophulariaceae
Lycium chinese L.	Kichi, matrimony vine	Solanaceae
Lycopersicum esculentum Mil.	Tomato	Solanaceae
Medinilla crispata Blume	Medinilla	Melastomataceae
M. hasseltii Blume	Medinilla	Melastomataceae
M. radicans Blume	Medinilla	Melastomataceae
Mentha longifolia Huds.	Longleaf mint	Labiatae
Murraya koenigii Spreng.	Curry-leaf tree	Rutaceae
Nauclea esculenta Afzel.	Pincushion	Rubiaceae
Ocimum canum L.	Hoary basil	Labiatae
Oenanthe javanica DC	Shelum	Umbelliferae
Ottelia alismoides Pers.	Pond lettuce	Hydrocharitaceae
Oxalis corniculata L.	Sorrel	Oxalidaceae
Pilea melastomoides	Sweet nettle	Urticaceae
Piper lolot C. DC	Pepper leaf	Piperaceae
P. caducibracteum C.D.	Pepper leaf	Piperaceae
P. umbellatum L.	Pepper leaf	Piperaceae
Pistacia lentiscus L.	Pistachio resin tree	Anacardiaceae
Pluchea indica Less.	Indian sage	Compositae
Polygonum hydropiper L.	Water polygonum	Polygonaceae
Staurogyne elongata Kuntze	Cross flower	Acanthaceae
Trachyspermum involucratum Walff.	Wild celery	Umbelliferae

*This list does not include species mentioned in the text.

Figure 32.—Culantro, the false coriander of Puerto Rico, used for its spicy leaves.

The fresh leaf of coriander has a disagreeable odor related to the origin of the name coriandes, from bedbug. If the leaf is dried the odor matures to something resembling that of the seed. In both forms it finds a wide usage in the tropics, in flavoring rice, in stews, and in soups, and with cooked meat. Although not often marketed as a leaf, the plant is common in dooryards, where it can be readily used. It is normally grown as an annual. If some flowering and seeding occurs it reproduces itself normally and is not conciously planted from year to year.

Parsley or perejil, *Petroselinum crispum* (Mill) Ngm. is not as well adapted to the tropics as is coriander, and is less often seen. It can best be grown as a potted plant in areas that are protected from excess heat. It does not necessarily flower, nor does it thrive in the tropics, but plants often survive several years, yielding a continuous quantity of ferny leaf used chiefly as a garnish, but to a minor extent to flavor food.

Fennel, or hinojo, *Foeniculum vulgare* Mill, is an aromatic perennial of the Mediterranean that is now widely distributed and frequently weedy. A rather versatile species, some varieties are used as the source of the seed, the spice of commerce, whereas others are used for the edible qualities of their leaves or fleshy leaf bases.

In the tropics fennel is now quite common. It succeeds best at altitudes of 500 meters or more. At lower altitudes the seeds are seldom produced, but this does not prevent the use of the leaves as flavoring both raw in salads or cooked. The leaves may also be dried and ground to be used as needed for flavoring.

Dill or eneldo, *Anethium graveolens* L., is not commonly seen in the tropics, but it has been introduced widely and is known to be well adapted. In Indonesia time has brought about changes in this spice, so that fully adapted forms are now available. It is grown commercially on a small scale, but probably more often for its spicy foliage then for its seeds, the usual spice. The leaves are used chiefly in soups and stews, but also have uses in folk medicine.

Chervil or cerafolio, *Anthriscus cerefolium* Hoffm., is a European annual with lacy foliage reminiscent of parsley, and used much the same way. It is rather more sensitive to the heat and is seldom seen in the tropics. The leaves are often used cooked in soups and stews.

Labiatae

The mint family is so widely distributed that it hardly needs introduction. There must be few persons who have not found it volunteering in their own backyards, or who cannot recognize a member of the family by the squareness of the stems, the diminutive irregular flowers, frequently in whorls in the axils of the leaves, or by the scent of the leaves themselves. Many of the members of this large family are spicy (see appendix) and are utilized cultivated or wild to give food a special touch. In contrast to members of the Umbelliferae the spice plants of the Labiatae are used chiefly for their aromatic leaves.

Perhaps the mints are known best, for every school boy has carried mint-flavored gum in his pockets. The principal mint species, *Mentha piperita* L. and *M. spicata* L., are native to the Mediterranean region, but now

widespread. The Japanese species, *M. arvensis*, is now the most widely distributed and important. The species hybridize easily, and give the taxonomists trouble. All 3 species are perennial herbs, grown in certain areas of the temperate zone as commercial crops, but only more recently in the tropics.

Mints have a variety of uses, as flavoring herbs, in cooking, in desserts and appetizers, in scents and perfumes. Their history in the Mediterranean is long and well recorded, for their medicinal uses have also been important. Mint leaves also serve in teas, as a garnish, and as a flavoring for candies.

The commercial preparation of mint is seldom the fresh or even the dry leaf, but the oils, removed from the leaf by steam distillation. For this purpose it is harvested in the tropics on a grand scale from commercial farms and dried before distillation.

In the tropics mint is a common enough herb, often grown in pots for small scale uses in the home. However, most of the growth is vegetative. Flowers are seldom produced, but this is an advantage, and prolongs the life of the plant. Spearmint, *M. spicata*, is better adapted to the tropics than peppermint, *M. piperita*, but *M. arvensis*, Japanese peppermint, while not the best in quality, is the easiest to grow.

The most important spices of the Labiatae are rather strong and are used principally with meat. Oregano is a good example. The name is used for the fragrant leaves of several species of the genus *Origanum*, and some confusion exists, especially when a distinction is attempted from marjoram. All are perennial plants of the Mediterranean region, but some are grown as annuals. The word oregano is frequently applied in the tropics to other savory leaved plants used as spices, but more properly its use should be restricted. The true oregano, *Origanum vulgare* L., and the Mexican "oregano," *Lippia graveolens*, are grown on only a limited scale in the tropics. A native *Lippia* of Puerto Rico is also called oregano (Fig. 33). They are chiefly confined to pots or produced on only a small scale. Marjoram (*Origanum majorana* L.) on the other hand, is a smaller plant much more suitable for home usage in the tropics. It should not be confused with *O. onites* L., pot marjoram, a more common but less desirable species. "Oregano" in the Caribbean frequently is used for the species *Coleus amboinicus* Lour.

Thyme, or *Thymus vulgaris* L. is a small Mediterranean plant with quite small, very pleasantly aromatic leaves. Normally harvested and dried when the plants are beginning to flower, thyme is well adjusted to northern climes, but is rare in the tropics. With slight precautions it can be grown in pots or the home garden for use on a limited scale.

Basil or albahaca (*Ocimum basilicum* L.) is a spice of the Labiatae from the tropics which has been accepted in the temperate zone as sweet basil. It is an old species, cultivated in India for centuries, and probably better known there than anywhere else. The genus itself is widely distributed in the tropics where related species are used for religious, medicinal, and insecticidal purposes. Basil is a small plant, rather bushy, and somewhat woody at the base (Fig. 34.) It is grown from seed as an annual, although in fact it is a perennial species. The foliage is normally removed and dried in order to prepare the condiment. An essential oil is removed by steam distillation.

Basil is already a tropical herb, perhaps the most important spice from leaves that has come from the tropics. It is well adapted everywhere and needs no special precautions. The leaves can be used fresh, or sun dried, in

Figure 33.—The oregano of Puerto Rico, *Lippia helleri.*

Figure 34. -Albahaca or basil, as grown for its leaves in Puerto Rico.

stews, with meats, or with vegetables. By custom it is often used with dishes that contain tomatoes. The liqueur chartreuse includes basil leaves in its recipe.

Three other spices seldom seen in the tropics are sage, or salvia, (*Salvia officinalis* L.), savory or aphedrea, *Satureja hortensis* L.) and rosemary or romero (*Rosmarinus officinalis* L.). On the small scale for which they are needed in the home, they can be grown in the tropical garden. A few sages have done very well in the tropics, and are used as spices, including *S. hispanica* L., in Indonesia.

Compositae

Among the plants of the Compositae useful as condiments, none is more important than the true tarragon, *Artemisea dracunculus* L. It is a bushy perennial from Southern Russia and western Asia, that has now been widely grown throughout the temperate zone, but is almost unknown in the tropics. It is widely used in sauces, with meat, and with vegetables, and in vinegar where its licorice or anise like aroma adds a distinctive touch.

Artemisia has numerous wild, aromatic species of which a few have been introduced to the tropics, and can be used as tarragon substitutes. Of these wormwood, or *A. vulgaris* L. seems to be the most promising, and has grown and produced well in Indonesia.

Other Families

Several species related to the onion (genus *Allium*) find their place in the tropics. The most useful of these is *A. schoenoprasum* L., known as chives, cebolleta, or cebollino, grown not for its bulbs, which are insignificant, but for its leaves which are used more as a condiment than as a vegetable. Two other species, *A. fistulosum* L., the Welsh onion, and *A. tuberosum* Roth., Chinese chives, are used in a similar fashion. These plants are not at home in the tropics except at higher elevations. Where grown, they are popular, and are often marketed. Under the special conditions of the home garden all three can be grown, and pot culture is recommended. A small number of plants protected from an excess of heat and sun, can provide large quantities of leaves throughout the year for use in home cookery.

In table 7 a list of species, the leaves of which are sometimes used for flavoring are given. In most cases very little information is available on the plants, and readers who can obtain some of the species are warned that caution is appropriate. The list is not complete, for it emphasizes species native or introduced to southeast Asia. Data on African and South American species are much more difficult to obtain.

Leaves Used as Tea

A wide variety of leaves are used throughout the world as teas. Many of the teas are really folk medicines that have seldom been investigated for their reputed values. Another class of teas are those that stimulate, usually because of the presence of the alkaloid caffeine. There may be teas also that are consumed only for the flavors, but this reason for drinking them is only

a minor one.

The tea of commerce comes from the leaves of *Camellia sinensis* L., a native species of Assam or India. Tea is a subtropical bushy plant cultivated from seeds or cuttings. It is very well known in the tropics, and much of the world's production has come from India, Ceylon, and Indonesia. It is found at the equator in Africa, especially at high elevations. The true tea has not thrived in most places in the New World but is sometimes found on a small scale (as in Brazil).

Tea bushes require several years to mature, are harvested regularly for 5 or 6 years thereafter, and then are cut back in order to permit new growth. Only the youngest leaves of the plants are harvested, and this stimulates new growth. Thus, harvesting every two weeks is necessary. The leaves are dried immediately to produce green tea, or fermented after withering and crushing. Caffeine occurs in the leaf as 2 to 5 percent of the dry matter. Tannin content is high, and gives the body desired to the tea. Other than as a stimulant tea has very little value.

Another tea, this one of American origin, is that made from the leaves of maté, *Ilex paraguayensis* the family Aquifoliaceae. This subtropical plant occurs wild and is extensively cultivated in Paraguay, Northern Argentina, and Southern Brazil. The use of maté is of ancient origin but the habit is now extensive and spreading. Maté is less astringent than "true" tea. It is somewhat bitter, aromatic, and very stimulating. The beverage is prepared by pouring hot or cold water over the crushed leaves. When the infusion is ready, it is drunk with a perforated tube, or one might say, a filtered soda straw.

Maté is at home in the subtropics, but can be grown with some care in the hotter regions. In the temperate zone other species of Ilex such as *I. cassine* and *I. vomitoria* have been used for tea.

A tea little known to the western world is khat, made from the leaves of *Catha edulis* Forsk. (family Celastracae), an evergreen shrub of Arabia and Africa. The leaves are eaten uncooked, chewed, or brewed fresh or dry into a tea. As with other teas, its stimulating principle is an alkaloid much like caffeine. The cultivation of khat is very old, probably outdating that of coffee.

The use of tropical leaves in other beverages should be mentioned. The leaves of Coca, *Erythroxylon coca* Lam. are used, after removal of the cocaine, to make the popular cola drinks. Several leaves used in liqueurs have already been mentioned. To them should be added those of anise and peppermint (*Mentha piperita* L.) used in creme de menthe.

A full list of tropical tea plants would be very difficult to develop. A short list of additional species, many of which are common, is given in table 8.

Table 8.—Other tropical plants, the leaves of which are used in teas.

Scientific name	Common name
Acalypha siamensis Oliver	Hermit's tea
Baeckea frutescens L.	Childbirth tea
Bidens pilosa L.	Spanish needles

Scientific name	Common name
Camelia japonica L.	Garden camellia
Cassia mimosoides L.	Japanese tea
Chloranthus brachystachys Blume	Tea scent
Citrus aurantium L.	Seville orange
Cratoxylon nerifolium Blume	Bebya tea
Cymbopogon citratus Stapf.	Lemon grass
Diplospora kunstleri Kong	Wild coffee
D. macaccenense Hook f.	Wild coffee
Ehretia microphylla Lam.	Himalayan tea
Gaultheria fragrantissum Wall.	Wintergreen tea
Hydrocotyle asiatica L.	Long life tea
Ilex latifolia Thunb.	Holly tea
Lycium chinense L.	Matrimony vine
Melaleuca leucadendron	Paper bark tree
Peperomia pellucida H.B.& K.	Greenhouse tea plant
Talauma ovata St. Hil.	Talauma tea
Vitis diffusa Miq.	Charek

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CHAPTER VII

Temperate Zone Green Leaves in the Tropics

Was it chance, climate, or luck that the principal agricultural-based civilizations of the past developed in the temperate zone? Perhaps the cold weather made advanced planning and organization necessary. Food and fuel had to be obtained in times of plenty and stored for the lean months. Those who couldn't plan moved towards the equator or perished. Eventually the strong civilizations of the north, particularly of Europe began to move south, where they profoundly influenced the history of the tropics. With the explorers went their foodstuffs, their edible plants developed in their own countries. Among these were edible green leaves.

Thus, it should come as no surprise that edible green leaves from northern climates are frequently seen in the tropics. They are often better known than the cultivated and wild greens found locally. But they are not necessarily happy in their new environments. The reasons are simple. Each species exists in a harmonious balance with its ambient. When the environment is changed the species often does not respond favorably.

Elements of the environment that limit green-leaved plants from the temperate zone are temperature and length of day. The normal life cycles of such plants are regulated to coincide with cold temperatures, when growth is slow, and warm spring and summer temperatures when flowering and seeding occur. Although both temperature and day length can be controlled on a small scale, control on the scale of commercial production is much more difficult to achieve. Temperate zone green-leaved plants are thus seldom at home in the tropics. But if their special requirements are met, they can be made to produce.

The Genus *Brassica*

Although about 100 species of *Brassica* have been described in Europe, Asia, and Africa, this genus is a particularly confusing one because of its many forms, its adaptation to many climates and ecological niches, its cultivated varieties and its noxious weeds. The species are mostly annual or biennial herbs. The biennials usually form a rosette of leaves during the winter season, often storing nutrients in thickened or tuberous roots. The mature plants are erect, sometimes branched, free of hair (usually), with pinnated lower leaves, and with white or yellow flowers. The flowers have 4 petals, 4 sepals, but 6 stamens.

The tendency to thicken, seen in the roots, is true also of leaves, stems, axillary buds, and flower clusters. It is probably this characteristic, and the edibility of most *Brassica* species that led to cultivation of a few species, and the eventual development through breeding, of many botanical forms and thousands of varieties. Most of the edible types are considered cool season crops. The principal species and varieties of *Brassica* that bear edible green leaves are listed below. Others are included in the appendix. The truth is that the relationship of the species and botanical varieties is not well known, and therefore other classifications are equally feasible.

Brassica integrifolia Schultz	Chevalieri, Tropical African cabbage
Brassica juncea L.	Indian mustard
Brassica campestris L.	
Pekinensis group	Chinese cabbage
Chinensis group	Chinese mustard
Perveridis group	Spinach mustard
Brassica hirta L.	White or yellow mustard
Brassica napus L.	Rutabaga
Brassica nigra L.	Mustard
Brassica oleracea L.	
var. *acephala*, forma *sabellica*	Kale
forma *viridis*	Collards
var. *botrytis* L.	Cauliflower
var. *bullata* D.C., forma *gemmifera*	Brussels sprouts
forma *sabauda* L.	Savoy cabbage
var. *capitata* L.	Head cabbage
var. *gongylodes* L.	Kohlrabi
var. *italica* Planch	Broccoli
Brassica rapa L.	Turnip
Brassica schiveperi Boiss.	
Brassica seninis Justen	Chinese cabbage
Brassica tournefortii Gouan.	

Cabbage

Cabbage is a generic term applied not only to a type of plant in which the leaves are closely packed, such as palm cabbage, but also to what is often called the "true" cabbage, *Brassica oleracea*, variety *capitata*. In contrast to plants of the type that fit the generic name, the "true" cabbage includes forms that produce loose leaves as well as the heading varieties. Collards or colewort are leafy varieties of cabbage grown, harvested, and eaten in much the same way as for spinach. The name cabbage, however, has its origin in words that mean heads.

The original cabbage was of the non-heading type and grew wild in the eastern Mediterranean. It is believed to have been extended throughout Europe by the Celts years before the time of Christ. The existence of wild cabbage in England, France, and Denmark has encouraged the impression, however, that cabbage originated in western Europe. The wild forms differ tremendously in morphology and eating qualities.

Experimental work in England has shown that the wild, headless cabbage can be bred within a few generations to form loose head. Or if the stems have a tendency to swell, the plants can be bred to form the turnip-rooted cabbages. The first cabbage varieties were therefore probably of the loose leaf type. The Savoy type cabbages of Southern Europe, which form rather loose types, are representative of the primitive type of varieties, but differ in their rugose or blistered leaves. Some are attractively colored by anthocyanins of the epidermis.

The headed cabbage, on the other hand, appears to also be ancient in origin. There is some suggestion that hard-headed cabbages came from northern Europe, but it is uncertain whether the historical distinctions found in the literature were only the result of growing similar varieties in different places. The heading tendency, for example, is much less evident in warm than in cold climates. Modern varieties can be conveniently divided into 5 varieties, depending on shape of the head (flat-headed, spherical, egg-shaped, elliptic, and conical. All these various types are still represented by at least a few existing varieties.

Cabbages are slow-growing biennials which have three distinct periods. In the first period the rosette of vegetation is formed. This is a relatively rapid phase, during the latter part of which the head forms. Cabbages then pass through a period of rest when the rudiments of the bloom are formed. Finally the inflorescence develops rapidly, forming of the plant an upright, branched, prolifically flowering structure. However, seed production dictates some modification of the growth pattern. The plants are removed about the time of frost, stored until spring, and then replanted. The heads are partially cut to permit the growing point to emerge with little obstacle.

Cabbage is definitely a cool season crop, and reaches its perfection in cold climes. Cold temperatures of winter are necessary to stimulate flower production. Frosts are well tolerated; the collards, in fact, are much improved in flavor by frosts. The bulk of the world's cabbages are grown in the cold climates of the Northern Hemisphere. Nevertheless, cabbage, perhaps better than any other temperate zone green, can be grown successfully in the tropics (Fig. 35).

Perhaps the tropical area where cabbage and related crops have been most thoroughly studied is the Philippine Islands. Here a wide variety of geographical conditions, altitudes, shores, etc., blend to form a mosaic of climates. Cabbages are grown throughout the year in high, cool, moist regions (Fig. 36). Nevertheless, during the cool months of the short day season cabbages are also successful in the lowlands. In the latter case the plants may be established during warm weather but plantings should be timed so that heading of cabbage corresponds to the cool weather.

Cabbages are not particular about their soil preferences. Earliness is associated with sandy soils, and high, late yields with clays. Soil pH of 6 to 6.8 is optimum. An important feature of the soil is its available moisture. An abundant supply of moisture is necessary for this crop. The soil is usually worked thoroughly and then formed into shallow beds of one or two rows. It is beneficial to incorporate an organic material or complete mineral fertilizer in the soil before planting.

Cabbage may be planted in special seedling beds, and then transplanted

Figure 35.–Cabbage in a garden clearing in the Caribbean.

Figure 36.—A hillside planting of cabbage, established and cultivated by hand, in the mountains of Puerto Rico.

or it may be seeded directly in the garden. The former method makes possible careful soil sterilization as well as special attention to nutrient status. However, transplanting always delays the crop to some extent. The seeds are planted not more than 1.5 centimeters deep, and germinate in a few days. Plants must be maintained in excellent condition, for those stunted by competition, drought, or poor nutrition do not yield satisfactory heads later. If plants grow too rapidly they may be held back by withholding water. Generally about 4 weeks are needed to produce suitable plants. Plants should be exposed to harsh conditions for about a week to harden them before transplanting. Plants that are too large at transplanting (stem diameter of 6 mm. or more) might have passed the juvenile stage. Exposure to cold temperatures can thus induce flowering instead of head formation. Transplanting in the garden is most convenient at about .5 meters, in rows one meter apart. However, optimum spacing depends on the variety. Plants should be removed from seed beds with some soil to avoid too much damage to the root system. Adequate irrigation is needed from the very beginning.

After the plants are well established they benefit from extra nitrogen fertilizer. Because cabbages are shallow rooted, they must be irrigated frequently. For such fast growing plants, weed competition is particularly deleterious. Commercial herbicides are often used after planting. Hand cultivation should be as shallow as possible to avoid damage to the root system. Cabbages are susceptible to attack by many insects, especially caterpillars, but control measures cannot be given here. It is interesting that in some areas dead worms collected on the plants are mixed in a spray to spread the diseases that killed them, a primitive but effective biological control. Nematodes may cause severe stunting.

Cabbage is ready for harvest 3 to 5 months after planting (Fig. 37). Although the leaves are edible at any time, the plants are generally left until a hard head is formed. The time required is chiefly a function of variety. Most cabbage harvesting is still done by hand. The stalk is cut with a sharp knife. For marketing heads are trimmed of most of the outer leaves. Once harvested, storage characteristics are usually pretty good. Fresh heads can be stored at cool temperatures up to 6 weeks without serious loss. Much longer storage is feasible if quality loss is tolerated. When stored cabbage is removed from the cold, rapid deterioration occurs.

Some varieties grown in the tropics are listed below. Many others have also proved suitable. Hybrid varieties are often widely adapted and are quite vigorous.

Variety of cabbage	Region where used
Ballhead Hybrid	Queensland
Greengold	Queensland
Greygreen	Queensland
Enhuizen Glory	Queensland, Tanzania, Philippine Islands
Vanguard	Queensland
Early Jersey, Wakefield	Queensland, Tanzania
All Seasons K-K Cross	Queensland

Figure 37.- Harvest time, and the most reliable way of getting cabbages out of the field.

Jubilee Hybrid	Queensland
Summer Pride	Sierra Leone
O S Cross	Sierra Leone, Philippine Islands
Copenhagen Market	Hawaii, Tanzania, Puerto Rico, Philippine Islands
Cape Spitzkool	Tanzania, Puerto Rico, Philippine Islands
Brunswick	Tanzania, Colombia
Emerald	Colombia
Golden Acre	Puerto Rico, Hawaii
Sucession	Puerto Rico, Hawa'i

Cabbage is one of the best sources of edible green leaves, not only because its yields are very good, but because of its nutritive value. Water content is very high, about 92%. It is a very good source of calcium and vitamin C, a fair source of A and B vitamins, and it is a good source of protein but only a fair source of energy. Because of its high production, it is usually an inexpensive food.

Cabbage is versatile in its uses. As a salad plant it is excellent, but some people object to its strong odor caused by a sulfur compound. As a cooked vegetable it is used in a variety of forms, including stews with other vegetables. It can be preserved by pickling to give sauerkraut.

Other Cole Crops

The leaves of practically all *Brassica* species are edible, but the strong flavors of some species are disagreeable or too strong for most people's taste. Most of the important species have been mentioned earlier. The edible leaves are usually not eaten, however, in special forms such as broccoli and cauliflower. Of the various species, Chinese cabbage, *Brassica campestris* L., is surely the most important except for cabbage itself.

As its name implies, Chinese cabbage is a native of eastern Asia. Its history is long, for it is believed to have been cultivated before the time of Christ. From there it was introduced to adjacent islands in Pre-Columbian times. Therefore, Chinese cabbage is well distributed and well known in the Asian tropics, but is little known elsewhere.

Chinese cabbage resembles lettuce in many ways. The leaves are usually rugose and are formed into heads which are less compact than the heads of typical cabbage. While heads form rapidly, sometimes in as little as two months after planting, they vary in shape. The Pekinensis forms are narrow and upright, and in fact resemble romaine lettuce. The Chinensis forms do not form solid heads but are more open, and resemble swiss chard, especially because of their prominent white petioles.

The species is a short-lived annual which usually is planted either during the winter or spring. It is highly responsive to differences in both temperature and day length. High temperatures, while useful in reducing flowering tendency, lead to bitter flavors and soft heads. High quality Chinese cabbage can only be produced at cool temperatures, such as 15 to 20°C. Day length also

influences plant growth. The long days of summer are conducive to flowering, but so are cool days.

Chinese cabbage is usually produced as a late fall or early summer crop. Unless special precautions are taken to protect it from long days, it is not grown for heads during long, hot summers. Nevertheless, something edible can be had from Chinese cabbage at all seasons and climates of the tropics.

Plants for transplanting are usually produced in carefully tended beds where frequent watering is necessary, and mulch can be used to maintain the humidity. The plants grow rapidly and are ready for transplanting 3 to 3 1/2 weeks after seeding. They require a rich, well-fertilized soil. After transplanting they are maintained in lush condition by applications of nitrogen fertilizer and by frequent irrigations. The mature plants may be ready for harvesting in as little as 20 days after transplanting. More frequently the total cycle from seeding to maturity is 2 or 3 months.

Chinese cabbage has many uses. It is commonly used raw as a salad, or is cooked as a green. It may also be fermented and stored in salt to give a unique dish. It is sometimes dried for later use. In addition, it can be stored under cool conditions for up to 3 months. Chinese cabbage is a good source of calcium and vitamins A and C. Because of its rapid growth it is a food produced very efficiently.

Areas of the tropics where Chinese cabbage has been very successful include Southeast Asia, the Philippine Islands, Puerto Rico, Central America, Sierra Leone, Nigeria, and Hawaii.

The leafy species of *Brassica*, collards, kale, and mustard, while less popular and more strongly flavored than the cabbages, merit more attention in the tropics for several reasons. They are more amenable to the continuous cropping desirable in the home garden. Because of their open structure they are greener. They are for their weight more nutritious than the cabbages. Whereas the former require a cool temperature, tropical mustards can be grown in the tropics almost year around.

As a summary, the *Brassica* species are very useful in the tropics when care is taken to give them appropriate environmental conditions and treatments. They merit more extensive trial in the home garden and more extensive breeding work to eliminate sensitivity to hot weather. In contrast to most green leaves of the tropics, *Brassica* species are easily available from seedsmen and thus available almost anywhere.

Other Leafy Crops

Endive and chicory. Two closely related leafy crops are sometimes grown in the tropics, *Cichorium endivia* L., endive, and *C. intybus* L., chicory. The former species is believed to have originated in Eastern India, probably from high elevations or cool climates. However, it is best known, and has been developed as a vegetable chiefly in Europe. In the tropics, on the other hand, endive has been grown frequently in tropical highlands where its cool requirements are met. Chicory originated in Europe where it has been used for a number of distinct purposes. It is seldom seen in the tropics, and indeed requires somewhat more stringent conditions than endive. Whereas endive is grown chiefly as an annual or biennial, chicory is known mostly as a perennial species.

Endive is a good substitute for lettuce in the tropics. Although a cool season crop, endive withstands heat better than lettuce. It is normally sown either in the fall or very early spring so that its growth cycle is finished before the coming of very hot weather.

The leaves of endive can be used as a fresh green in salads, or as a cooked green. Their flavor is strong and bitter, however. In order to avoid this taste and to produce a more succulent product, the leaves are blanched before harvest. This is done by gathering up the large outer leaves into a loose bundle and tying them with a string. Blanching requires 10 days to 3 weeks in the tropics. When the plant is harvested by cutting it away from the roots, the large, outer leaves are discarded. Blanching must be avoided in wet weather because rotting of the inner head easily occurs. Some varieties, such as Broad-leaved Batavian, form loose, natural heads, and these are self blanching, and less susceptible to rot. Other varieties are sometimes blanched by crowding plants in the row.

In common with most greens, endives requires rich cultural conditions, high fertility and lots of water. Seeds should be started in the area where the mature plants are desired, as they do not transplant well. Plants are spaced 25-30 centimeters apart. The plants should be forced along to maturity as rapidly as possible. In the tropics endive has been reported successful, chiefly at high altitudes, in Puerto Rico, the Philippine Islands, West Africa, Madagascar, and Hong Kong.

In contrast to endive, chicory is seldom seen in the tropics, and merits further trial, especially at high altitudes. It is somewhat more fussy than endive in its requirements, and probably this accounts for its neglect. Chicory is best known as an adulterant for coffee. The perennial tap roots are washed, sliced, dried, and ground to make a coffee-like product. Chicory is also used as a pot herb, but the coarse leaves are so bitter that two changes of cooking water are recommended. Such leaves are seldom marketed. However, although seldom practiced, the leaves of chicory can be blanched in much the same way as those of endive. Another practice is to bank soil around the plants to blanch the leaves.

Chicory is at its best when blanched in the dark. The roots are removed at maturity and stored in a cool place until desired. Then, when placed in a warm place, they begin to sprout. Although this can be done in light, in the darkness the new leaves are blanched and tender. If soil is heaped over the roots, or if straw or other substitute is used, the germinating shoot forms a soft, delicate head commonly known as whitloof. This vegetable is highly esteemed.

Chicory appears to be widely adapted, for weedy forms have been introduced throughout the temperate zone and in some parts of the tropics. Because of its excellent quality as a specialty leaf vegetable, it merits attention to see if its culture can be adapted to the tropics.

Spinach. The word spinach is often used for many kinds of edible green leaves. Nevertheless, its most widely understood usage is as a common name for the species *Spinacea oleracea* L., the spinach of the temperate zone. The member of the family Chenopodiaceae was introduced into Europe from Southwestern Asia, where it has continued to evolve as a cool season crop. Spinach may be eaten either raw in salad, or cooked as a pot herb.

The habit of spinach is to develop a seed stalk rapidly in the tropics. This characteristic is related primarily to day length but also is influenced by temperature. Therefore, in most areas of the tropics spinach is not successful. It is rarely grown, and then only at altitudes of 1,000 meters or more.

Spinach grows rapidly, especially when well fertilized with nitrogen, and thus needs a rich soil and much attention. A rosette of leaves forms first, from which the flower stalk originates. Normally the plants are harvested just once from 6 weeks to 3 months after planting. For all its vaunted food value, its high vitamin, mineral and protein content, spinach has one defect, a high content of oxalic acid. Because oxalic acid combines with calcium to make it unavailable to the body, too much spinach in the diet can be detrimental. In contrast to most plants, spinach is relatively rich in the essential amino acid methionine.

Species of plants, like people, differ in their ability to adjust away from home. The true spinach is a plant that has not found a home in the tropics.

Swiss chard and beet greens. One of the most ancient of European vegetables is *Beta vulgaris* L., a very diversified species with many cultivars including the well known sugar beet, the table beet (red and yellow forms) and swiss chard. Lesser known forms include other chards (red, "black"), the sea-beet, the silver leaf beet, and the mangold. The species also has wild forms that extend from the Canary Islands through the Mediterranean to western India. They are eaten as pot herbs. The origins of the numerous varieties of *B. vulgaris* are not well known, but many forms were described before the time of Christ.

Although the leaves of all *B. vulgaris* varieties, including table beets and sugar beets (Fig. 38) are edible, only Swiss Chard merits attention here. The other chards are too difficult to obtain and are seldom seen on the market. Chard is simple to grow, and very tolerant of differences in soils. Although a cool season crop, chard is quite adapted to cool regions of the tropics, can tolerate some heat, and produces reasonably well in the lowlands. The seeds are large and encased in a corky coat. They germinate rapidly and furnish edible greens within a few weeks. Leaves may be cut at any time for use as a spinach (never as a salad green). With care the entire loose head may be taken, leaving the base of the leaves and part of the stem so that regrowth may occur. A better practice is to cut only the large outer leaves. This continuous cropping feature of chard recommends it for the home garden. Furthermore, chard is biennial and may be cropped a second year unless seed stalk formation occurs. Leaf stalks are sometimes prominent, and may be cooked separately from the leaf in the form of celery or asparagus.

Yields of chard are spectacular. Careful culture, based on small scale experiments, has yielded up to 400 metric tons of edible greens per hectare in the tropics.

Varieties include both smooth-leaved or savoyed (rugose) types. No special varieties have been developed for the tropics, but those from temperate zones such as Fordhook Giant, Dark Green Lucullus, and Large Ribbed White serve well in the tropics. A red-leaved variety has been given the name Rhubarb.

Swiss chard has been successfully grown in Tanzania, West Africa, the Philippine Islands, Puerto Rico, Curacao, and without doubt in many other areas of the tropics. As an old standby, a prolific and dependable source of

Figure 38.—A sugar beet field in Puerto Rico, with large edible leaves.

greens, it merits much more extensive use.

Celery. *Apium graveolens* L., is not usually grown for its green leaves, but its fleshy petioles. As a popular salad vegetable as well as pot herb it merits consideration here. It is a wild plant of marshy places, found native from as far north as Sweden and as far south as Algeria. However, by now it is widespread as an occasional weed throughout the temperate zones. It is apparently a Johnny-come lately among cultivated vegetables, although it was used earlier as a wild plant for medicinal purposes. It is interesting to note that a tuberous form of celery exists in the temperate zone, celeriac. The thickened crown is used as a vegetable. Leaves and petioles of celery may be dried for later use.

The culture of celery is rather specialized, especially when blanched petioles are desired. Its requirement for cool weather is met with only at higher altitudes of the tropics. At higher temperatures (lower altitudes) the petioles of celery tend to be tough and stringy. A variety grown in the Philippines with short, compact stems is heat resistant. Rich soils are required, and this generally involves the use of manure. The small seeds are normally germinated in a separate bed, where they are seeded very near the surface. Seedlings are transplanted when 5 or more centimeters high, and must be protected from the sun for a few days. High nitrogen fertilizer and frequent irrigation is essential for best growth. The growing season is rather long, about 5 months. During the last few weeks green varieties are sometimes tied up with paper to blanch the petioles.

Because of its long season and special requirements celery cannot be recommended as an important source of edible green leaves. It has been grown successfully, however, in Tanzania, Philippine Islands, Puerto Rico, Hong Kong, and other parts of the tropics.

Miscellaneous Species

A few green leaved crops from the temperate zone are seldom seen in the tropics but for completeness should be mentioned here (Table 9)

Table 9.—Miscellaneous green leaves of the temperate zone seldom seen in the tropics.

Common name	Scientific name	Origin
Mountain spinach	*Atriplex hortensis* L.	Europe
Dandelion	*Taraxacum officinale* L.	Europe
Garden cress	*Lepidium sativum* L.	Europe
Corn salad	*Valerianella olitoria* (L.) Poll	Europe
Rocket salad	*Eruca sativa* Mill.	Mediterranean region
Rhubarb	*Rheum rhaponticum* L.	Southern Siberia

Ground Ash	*Angelica archangelica* L.	Europe
Chervil	*Anthriscus cerefolium* (L.) Huffm.	Europe

Thus, it can be seen that while temperate zone green leaves are not exactly strangers to the tropics, neither are they perfectly at home. Most species can be grown successfully at high altitudes or during the cool season. On the other hand, a few are of much value in the hot, moist tropical lowlands.

CHAPTER VIII

Lettuce in the Tropics

The queen of the salad plants, the leaf that is synonymous with salad in most of the temperate zone, that exquisite, crisp foundation for the salad dish that also shreds into a fine and almost neutral medium for a variety of tasty sauces, is. of course, lettuce, *Lactuca sativa* L. Lettuce is not only salad, but it is money, a vegetable crop of sizeable importance to temperate zone economies. It is a modern crop that has emerged from primitive agriculture to be one of the most tenderly handled farm products, yet it is produced in a mechanized manner surpassed in few instances. Fortunes are made and occasionally lost in lettuce as growers scramble to anticipate and to dominate the vagaries of the lettuce market. With respect to lettuce, society has reached new heights of agricultural perfection, and marketing integration. It is just a leaf, but there is no other leaf like lettuce.

Lactuca, the genus to which lettuce belongs, comes from the latin word *lac* which refers to the milky juice found in all species. The plants are annual or perennial, mostly herbacious, and mostly distributed throughout the tropics. No systematic attempts have been made to resolve the taxonomy.

The genus *Lactuca* has its origin in the basin of the Mediterranean, where four closely related species occur. These, like so many weeds of the area, are now widely distributed. One, *L. serriola*, inhabits the south shore. In many ways, though wild, it resembles cultivated lettuce. Furthermore, it can by hybridized with lettuce, and apparently such hybridization occurs in nature, even without the help of man. The rather similar morphologies, the fact of hybridization, and the similarity of chromosome number suggest that cultivated lettuce originated from something like this wild species. On the other hand, the wild *L. serriola*, as we know it, has also undoubtedly been influenced by its proximity to the cultivated forms. The interchange of germ plasm has probably been continuous. The result has been the production of a cultivated species with a high degree of genetic plasticity and a wild species that has spread throughout the tropical world.

Paintings in Egyptian tombs dating from about 4500 BC reveal a type of lettuce with long pointed leaves, not much different from romaine lettuce. Lettuce was eaten by the kings of Persia as early as 550 BC. It was cultivated at a very early date in Greece, and later in Rome. The varieties of lettuce were leaf types. In a "herbal" or plant notebook of 1543, a lettuce in bloom is depicted, but with the name *Lactuca capitata*, the first historical record of head lettuce. Lettuce introduced to China in 600 to 900 AD developed along different lines, and in fact the fleshy stem became the principal part eaten. Lettuce was introduced into the New World with almost the first of the explorers, but the records show that it was first cultivated in the countries of the Caribbean.

Modern varieties of lettuce may be divided into 4 groups. The cos lettuce varieties are those such as romaine with long, upright leaves and a marked midrib almost to the tip. The tip of the leaf is blunt. The leaves are somewhat folded and grouped into loose heads. Leaf lettuce varieties (Fig. 39), on the other hand, are almost orbicular, and rather prostrate. The midrib

Figure 39.—A leaf-lettuce, Black Leaved Simpson, that does well in the tropics.

is much branched into smaller veins. Cabbage lettuce has much the same type of leaf but the leaves are gathered into a tight and succulent head. Asparagus lettuce varieties are seldom seen. The young stems are tender and edible whereas the light grey leaves are unpalatable. In addition to these, many primitive forms have been found that do not fit well into any classification.

The life cycle of lettuce is closely related to its cultural requirements. The general tendency of lettuce is to form a rosette of leaves near ground level during the cool months of winter or spring. As temperature increases, flowering is stimulated. From the rosette develops an upright stem, characterized by few leaves, that rapidly comes to flower. Thus, lettuce is an annual plant, or when planted very late in the year it can be said to be a biennial. The annual habit and the tendency to flower when temperatures are too high are characteristics which influence the success of different classes of lettuce in the tropics, but within each class, varietal differences with respect to heat tolerances are well known.

The most tolerant of the lettuces to heat are the cos varieties. Most such varieties were developed in the warm southern regions of Europe, but cool-requiring varieties are also known in England. The head type lettuces are the most demanding in their environmental requirements, while the leaf varieties are variable and intermediate.

In contrast to its heat sensitivity, lettuce is not responsive to photoperiod changes.

Lettuce has little value as a food. Its content of water is 94-95 percent. Protein, and vitamin B and C contents are much lower than those of almost all other green-leaved vegetables. Lettuce contains worthwhile amounts of calcium and vitamin A, however. The chief value of lettuce in the diet appears to be that it adds bulk, and serves a a medium for other items.

Many varieties of lettuce have been tested in the tropics. Most of these that have done well are listed in table 10. The varieties Pennlake, and Imperial 847 are good and seed is usually available. The soft headed variety Mignonette should be very good for the home garden. The old standby, Slowbolt is the best known leaf variety in the tropics. The varieties from Hawaii were bred there for heat resistance and merit further trial.

Soil Requirements

Lettuce is grown throughout the world on many different types of soils. The commercial production in New York is chiefly on muck soil rich in organic matter. In California the soils are much lighter and loamier, or even somewhat sandy. A heavier soil is desirable when the crop matures in hot weather. The root system of lettuce is not extensive, and thus the soil must be capable of holding sufficient water. Nevertheless, poor drainage is not tolerated. Lettuce does not thrive on soils too acid in reaction, but it can tolerate some alkaline soils. The optimum soil pH is 6-6.8. Liming an acid soil in excess of needs can cause chlorosis of lettuce.

Modification of the Climate

In the tropics (Fig. 40) lettuce is generally grown at high elevations of

Figure 40. -Gardening for lettuce on a small commercial farm of Puerto Rico.

1,000 meters or more. When grown in coastal lowlands it is usually successful only during the cooler months of the year. Nevertheless, on the scale of the home garden some modification of the micro-climate is possible to extend the season when lettuce can be successfully produced.

The most important climatic modification desired is the reduction of temperature. High temperatures not only lead to bolting, but are also responsible for the bitterness of lettuce. Any of the following methods are useful: partially shading lettuce with plastic screens, slowly maturing plants of other crops, or of *Lactuca indica* L., maintaining cool conditions near the soil by appropriate watering, or mist spray during hottest hours of the day.

Structures built to give shade have the further advantage of protection of the plants from torrential rains. Screens break large drops into small particles, which usually do not harm the delicate new leaves.

Table 10.—Lettuce varieties reported as successful in the tropics

Head Lettuce	Note
Great Lakes, especially 118,456,659	High elevations
Iceberg	High elevations
New York (Webb's wonderful)	High elevations
Trocadero improved	High elevations
Oswego	Middle elevations
Calmar	Middle elevations, Mildew resistant
Imperial 44,847	Middle elevations
Sutton's	Middle elevations
Yatesdale	
Winterlake	
Pennlake	Medium elevations
Minetto	Heat resistant
Laepili	Medium altitudes
Kulanui	Medium altitudes
Kauwela	Heat resistant
Leaf and Cos Lettuce	
Anuene	Tipburn resistant, heat resistant
Mignonette	Heat resistant
White Boston	
Black Seeded Simpson	
Early Curled Simpson	Middle elevation
Slobolt	Heat resistant
Ruby	Heat resistant
Salad Bowl	Heat resistant
White Parris Cos	Heat resistant
Parris Island Cos	Mosaic tolerance

Culture

Lettuce seeds are small, and the plants established from them are weak and slow to establish themselves. Special care in starting and tending plantings is desirable, and pays dividends in terms of future yields. Shallow wooden boxes or flats are convenient for sorting the plants. The soil should be loamy, finely sifted, fertile, and sterilized (small quantities of soil can be sterilized in the oven of the kitchen). The seeds planted in furrows can be covered with about .5 centimeters of fine soil. Protection from ants, which carry off the seed, may be necessary. Germination requires cool temperatures and these may be hard to obtain in the tropics. Watering should be managed with extreme caution. When plants have grown to the 4 or 5 leaf stage they should be transplanted without pruning to the garden beds of carefully prepared, fertilized soil. The beds should be watered in advance and then allowed to drain so as to avoid mud on transplanting. If the seed flat is also watered shortly before planting, the seedlings can be removed easily with minimum damage to the roots. The plants are transplanted at distances of 15 to 20 centimeters.

As an alternative, the lettuce seeds may be scattered over the very carefully prepared bed, covered with a light cap of soil, and watered with care. After germination occurs the extra plants can be thinned out, leaving the largest to continue growth.

The newly planted beds need some protection from hot tropical sun and from torrential rains. Temporary shelters may be useful, or if shade is not too intense, may be used throughout the growing season. Plantings must be irrigated with care. Subsoil irrigation is a common practice. Because of their shallow root system, lettuce needs frequent watering. Several weeks after transplanting, a fertilizer high in nitrogen (such as ammonium sulphate) is required to keep plants in a vigorous, succulent, condition. The beds should be weeded periodically, and plants that begin to bolt (develop flowering spikes) should be removed. If such plants are caught early enough they are still useful as salad.

Still another convenient way to grow lettuce, especially the leafy varieties, is to sow or transplant among growing corn, tomato, pepper, or eggplants. The shade is beneficial for the lettuce and the plants usually complete their development before the shade-giving crop begins to mature.

A variety of insect pests attack lettuce, but these are seldom a serious problem. Because the life cycle of lettuce is short, diseases are not usually severe. It is beyond the scope of this book to consider pest control problems.

One advantage of leaf lettuce plantings is that some leaves may be harvested at practically all seasons. Even the small plants are edible. The larger leaves of developing plants can be removed at any time. An alternative means of harvest is to cut all of the leaves of the plant without damaging the growing point. A new set of leaves will rapidly develop. Or, the entire plant can be removed from the soil, and the root cut away. The more tender portions of the plant receive some protection from the coarser outermost leaves. The bulk of the leaf lettuce harvest can be expected 35 to 40 days after sowing. Transplanting delays maturation.

Head lettuce varieties are normally not harvested until a firm head is produced (Fig. 41). Two or three months of growth are usually required. The

Figure 41.—Head lettuce grown at a medium elevation in the tropics, showing a semi-solid head.

hardness of the head is determined by feeling, for appearances are not reliable. The interval when head lettuce is best for harvest may be very short during warm weather. The outermost leaves are seldom suitable, and are cut away.

The growing of lettuce seed is a special and interesting operation quite unlike the production of the green leaf. The heat of summer weather is necessary to stimulate flower stalk formacion (Fig. 42). In the case of head lettuce, the heads are often forced open to permit the stalk to emerge.

Distribution and Experimental Studies in the Tropics

Lettuce is not grown throughout the tropics, although it can probably be grown almost anywhere. It is produced in Queensland on a commercial scale. In small quantities it is produced in Hong Kong, the Philippine Islands, West Africa, and the Caribbean. The culture of lettuce in the tropics has probably been most highly developed in the Philippine Islands.

Although not of major importance anywhere in the tropics, lettuce has been investigated in many agricultural research institutes. Variety trials have been reported in Tanzania, Trinidad, Curacao, New Britain, and the Philippine Islands. Breeding of heat resistant varieties has been done in Hawaii.

Growth rate and fertilization was studied in Ghana. In the Philippine Islands lettuce has been well studied from the agronomic standpoint. Controls of diseases with sprays and drenches was reported from Trinidad. In Queensland the disease known as tipburn has been investigated with respect to minoral nutrition. Seasonal effects on vitamin content were found in Puerto Rico.

Because lettuce is a green-leaved vegetable of choice, good, dependable varieties are needed for the tropics. Further searches for heat resistance in the species of *Lactuca* are desirable, and more breeding is necessary in order to develop truly heat resistant varieties. Until extensive efforts are made, the queen of the salad plants will have only a modest place in the hot tropics.

Other Species

In addition to *Lactuca sativa*, other species of lettuce are sometimes used as food. *L. alpina*, or mountain sow thistle is a weed of Europe, the milky stem of which is peeled and eaten by the Laplanders. The species *L. plumieri* grows wild in Southern France where it is used for its edible leaves. In the tropics of the Orient the species *L. indica* L., is commonly grown for cooked greens, but can also be eaten as a salad. It is an erect, annual herb with bright yellow flowers. This species of lettuce may be used as a light shade for *L. sativa*, or for other vegetables. An African edible species is *L. taracifolea*, and in the near east is found *L. tuberosa*. L. *intybacea* is widespread through the tropics. It is a tall branching herb of which entire young leaves are taken for cooking. The appendix can be consulted for names of other edible species.

From the European species *L. virosa* comes a sedative or narcotic, lactucarium, sometimes known as lettuce opium. It is found to some extent in all of the cultivated species. Few of those who enthusiastically eat their salads daily suspect that they are being dosed in small quantities with such a drug.

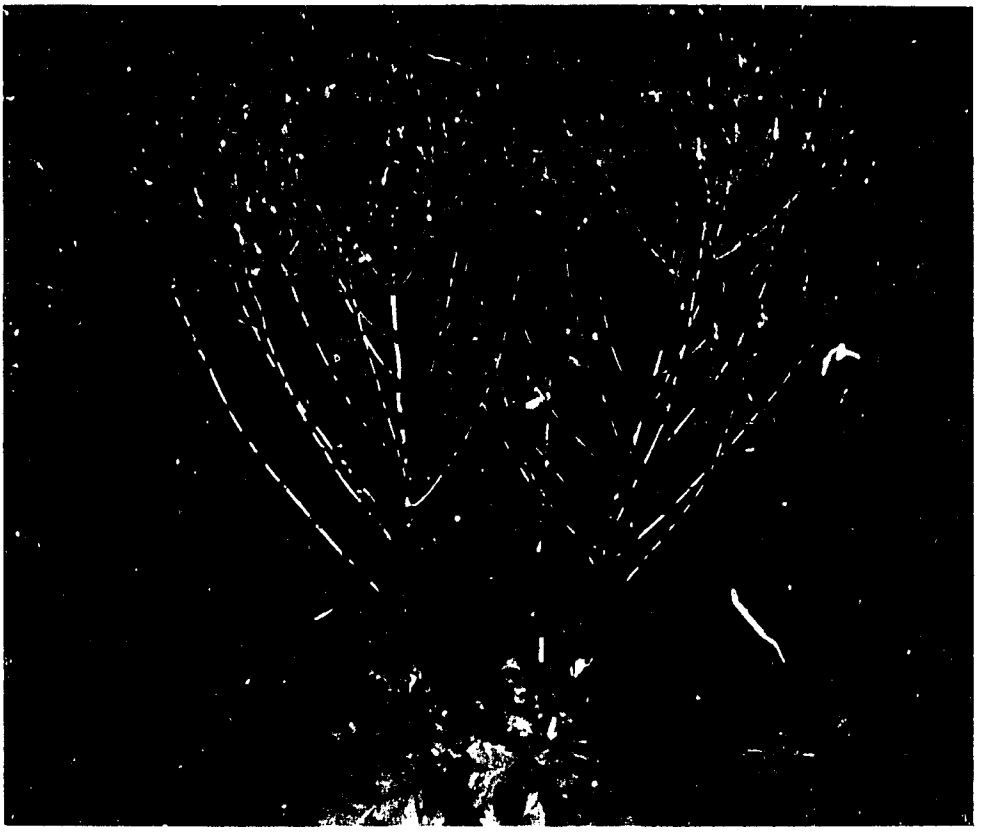

Figure 42.– Lettuce flowering.

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CHAPTER IX

Tropical Leaves That Are Poisonous

Although the leaves of the vast majority of tropical species are harmless, many poisonous species also occur and some are common. Because in this book over 400 species with edible leaves are mentioned, it would be a tragic error to believe that all leaves are edible, or that by simple trial and error the edible can be distinguished from the inedible leaves. Persons with a strong interest in edible wild plants are cautioned to identify plants carefully before testing their edible properties, and then to move with extreme caution.

The subject of plant poisoning is a very complex area treated in detail by numerous texts. As a general rule the plants of no one family can be singled out as particularly dangerous, but some families have more poisonous species than others (Table 11). Many edible plants have near relatives with poisonous parts or are themselves poisonous at times. Not every individual of a poisonous species is necessarily poisonous. Of a poisonous plant some parts may be poisonous while other parts are not. These parts may be poisonous at one time, and not poisonous at another. Leaves, for example, are most often poisonous when they are mature, but exceptions occur. Fruits, on the other hand, are often most poisonous just before maturity, but on maturity the poisonous substances are remetabolized. Seeds are particularly likely to be poisonous. Furthermore, plants that are very common and are not thought of as poisonous may be poisonous under certain circumstances, for example, when they accumulate toxic substances from the soil. Species of plants that are toxic to one species of animals are not necessarily toxic to other species. Thus, the entire subject of toxicity is complicated by special considerations. When plants are known to be poisonous, very special knowledge of the conditions under which they are not toxic or can be detoxified is necessary. Even the experts do not have all of the facts. Thus, with leaves a good rule is, "if in doubt, don't."

The poisonous substances in plants can be classified in many ways. For example, they can be considered primary and secondary substances. The primary substances are those which are common to all, or almost all plants, play an important role in the growth and metabolism of the plant, and are necessary for the continuance of plant life. Such primary substances are seldom poisonous. However, under unusual conditions, and occasionally even in normal circumstances such substances accumulate to the point that they are toxic. The second group of substances (secondary substances) are not found in all plants but occur especially in certain species that we identify as poisonous. Secondary substances are not necessary to the normal metabolism of the plant but fill special roles. It is generally believed that poisonous substances give the plant some protection from animal pests, and that they have thus evolved as mechanisms of protection. In the majority of the poisonous species the function of the poisonous substance is unknown. In addition to these classes of poisonous substances, poisons can exist in the leaves that were

taken from the soil and then retained or partially metabolized by the plant.

Poisonous plants can be classified by their physiological actions which differ considerably, but three classes can be distinguished. Some poisonous plants are toxic on contact. Their effects may be immediate, resulting in itching or pain, or may be delayed, with itching, dermatitis, or blistering occurring several days after contact. The resulting condition can last for a few hours or for days and weeks. The poisonous substance from such plants is often found in the milky juice or resinous secretion.

Such poisoning by contact must be distinguished from mechanical irritation (Fig. 43). For the sake of completeness a few leaves that mechanically irritate are considered here, but such irritation may not be associated with poisonous substances. In a few cases mechanical irritation and contact poisoning go hand in hand.

A second class of substances includes those that interfere with normal bodily functions and thus are usually not harmful unless ingested. Such substances may be immediately toxic in small quantities, may be chronically toxic over long periods of time, in which cases effects are accumulative, or they may be toxic only when taken in such quantities that the body cannot throw off the effects rapidly enough. The principal compounds are classified as alkaloids, glycosides, resinoids, and organic acids. Inorganic compounds, such as selenium, also can be classified here.

A final important class of plant poisons, but one more important for animals than for man are those that sensitize the skin to light. After ingesting sufficient quantities of the foliage, and only after exposure to sunlight, characteristic diseases develop which can result in death. Skin color apparently can provide some protection against photodynamic plant poisoning, perhaps by impeding the deep penetration of light rays.

A classification of poisonous principles of plants given by J. M. Kingsbury (1964) is useful to point out the diversity of plant poisons:

- Alkaloids
- Polypeptides
- Amines
- Glycosides
  - Cyanogenic
  - Goitrogenic
  - Irritating oils
  - Coumarin derivatives
  - Steroid and triterpenoid derivatives
    - Cardiac glycosides
    - Saponins
- Oxalates
- Resins and resinoids
  - Toxalbumins
- Minerals
  - Copper, lead, florine, manganese
  - Nitrogen

Figure 43.—Ortiga, *Urera baccifera*, a stinging nettle of the Caribbean.

As nitrates, nitrites, nitroses, and gaseous oxides

Selenium

Molybdenum

Compounds causing photosensitization

Primary photosensitization

Heptagenic photosensitization

From the standpoint of chemical constitution the most important group of poisonous substances found in leaves are alkaloids. These are secondary plant substances, always organic in nature (contain carbon) and always containing nitrogen. In addition, they are normally physiologically active in animals, that is, they profoundly influence normal physiological processes, and because these effects are disruptive, the substances are poisonous. Alkaloids are potent compounds often active in very small quantities. Much of the value of folk medicine lies in the utilization of naturally occurring alkaloids. On the other hand, alkaloids have a long history of use in legitimate medicine, and of abuse as poisons for human beings.

Alkaloids are most common in seed bearing plants, especially the Dicotyledons. They are uncommon but not unknown in fungi and simple plants (cryptograms). They are not very common in Monocotyledons. More than 2000 alkaloids have been described, and new compounds are constantly being discovered. Extensive searches have been made of the flowering plants in search of new alkaloids of possible medicinal value. One report by J. J. Willaman (1961) lists 3671 species known to contain alkaloids. This is only a very small portion of the number of species of plants in existence. In about half of these species the leaves themselves contain alkaloids. Since some alkaloids are the most deadly of poisons, experimentation with new species should begin by checking the species name against the body of information already available, such as the above reference.

Certain plant families have more alkaloid-bearing species than others (Table 11). However, the distribution of particular alkaloids and classes of alkaloids throughout the plant kingdom is so irregular that no generalization or safe rules are possible. It must be remembered that many edible plants, especially potato, contain alkaloids, and that in small or normal quantities these plants are not considered poisonous.

Many plant poisons belong to a class of substances called glycosides. These are usually bitter, white, and crystalline. Compounds of many types are held together in this group solely by the fact that their molecules include sugar side chains which increase their solubility in water. These sugars may be broken from the main molecule (hydrolyzed), an action which often increases the effects of the poisonous substances. Unfortunately, many alkaloids are also glycosides, and thus the classes overlap.

The cyanogenic glycosides are substances which yield the extremely poisonous gas hydrogen cyanide (prussic acid) on hydrolysis. These are very common throughout the flowering plants. In the Rosaceae the poisonous principal is called amygdalin. The physiological action of HCN is to inhibit respiration at the cellular level, thus causing a type of asphixiation. Hydrolysis occurs readily, and can be used to rid the tissues of the poison, which escapes as gas. Because this type of compound is so important in cassava (*Mani-*

hot esculenta) it is discussed more fully in chapter II.

Goitrogenic glycosides are those that prevent the body from accumulating iodine, and thus stimulate the formation of goiters. Species of several families, the Cruciferae, Rosaceae, and Umbelliferaceae are especially prone to this type of poison. Effects may be accumulative, and acute poisoning is unusual.

Table 11.—Some families of plants with many alkaloid-containing species

Family	Number of poisonous species
Amaryllidaceae	120
Apocynaceae	220
Compositae	200
Euphorbiaceae	75
Labiatae	50
Lauraceae	65
Leguminosae	500
Liliaceae	100
Loganiaceae	70
Menispermaceae	70
Papaveraceae	100
Ranunculaceae	125
Rubiaceae	175
Rutaceae	180
Sapindaceae	45
Solanaceae	260

Oils which are glycosides occur in the Cruciferae as isothyocyanates, and as other substances in Ranunculaceae. While usually recognized as skin irritants, they can be toxic if ingested in excessive amounts.

Coumarin, under appropriate circumstances of fermentation or ensilage, can be converted into a poisonous glycoside which acts as a hemorrhagic agent. The compound, and poisoning resulting from it, are chiefly associated with the clovers (*Melilotus*).

Steroidal and triterpenoid substances can be divided into the cardiac glycosides, such as digitalis, and the saponins. The cardiac glycosides are particularly potent substances found principally in the Scrophulariaceae, the Liliaceae, and the Apocynaceae. The saponins are very widely scattered throughout the plant kingdom. Their action is chiefly to cause gastrointestinal irritations.

Oxalic acid and oxalates are normal, widespread substances that can be metabolized by the body in small quantities, but which are poisonous if taken in excess. The soluble oxalates reduce the level of calcium in the blood.

The insoluble forms occur as crystal raphides that irritate the mouth and throat on ingesting them. The soluble oxalates are widespread and often reduce the value of otherwise very nutritious leaves. Some examples of leaves with high oxalic acid content are rhubarb, spinach, beet green, and *Portulaca*. On the other hand, most species of aroids (Araceae) contain insoluble oxalates.

Resins or resinoids are a variety of compounds found in sap that harden into vitrious substances, and are inflamable. The poisons of the milkweed family (Asclepiadaceae) are of this type.

Occasional specialized proteins, toxalbumins, are found, which have unexpected physiological effects. These include the agglutination of erythrocites, and often powerful enzymatic action. The leaves from castor bean (Fig. 44) and tung contain such proteins.

Inorganic or mineral substances often are associated with poisoning. This may be due to an excess of these substances in the soil, to the selective absorption and accumulation of such substances by certain plants that have an affinity for them, or to the residues left by pesticides sprayed on the plants. Selenium is actually required by some species, such as *Astragalus*, and such plants reveal the presence of selenium by their own abundant growth on selenium-containing soils. Molybdenum may poison by itself, or by its low concentration may stimulate copper poisoning.

Nonorganic compounds produced by the plants, including nitrates, nitrites, nitroses, and even gases of oxidized nitrogen, released by fermentation processes, can be quite toxic. Unfortunately these compounds are very widespread including among species generally thought to be edible (lettuce and sweet potato leaves, for example). Sometimes external agents, such as herbicides, stimulate excessive production of these compounds, so that normally safe leaves become poisonous. Nevertheless, poisoning is usually confined to animals.

Photosensitization compounds are called primary if, as in the case of pigments from buckwheat, the substances themselves cause the poisoning when the skin is exposed to the sun. If the compounds are metabolized into poisonous pigments, after ingestion, the effect is called heptagenic photosensitization. Such compounds occur in the leaves of Lantana, *Tribulus terrestris*, and *Brassica napus*.

Thus, the poisonous substances from leaves are extremely varied in nature, physiological action, and distribution. In fact, it is frightening to know that so many leaves are poisonous.

At least 10 percent of the species of plants in every environment bear poisonous leaves. Nevertheless the probability of poisoning from most plants is very small. The reason is that in most cases during the normal course of events the contact between plant and human being is too inconsequential to permit poisoning. Eating the leaves provides a very intimate contact, but even so, depending on the kind of poison, quantities of some poisonous leaves can be eaten without causing poisoning.

In considering the plants with poisonous leaves it is not necessary, desirable, nor possible to list all of the poisonous species here, since this book is a treatise concerning edible leaves, not poisonous ones. The leaves that are treated are only those of common plants widespread throughout the tropics,

Figure 44.—The castor bean, poisonous plant, the leaves of which are processed for eating.

common to the garden (including as weeds), and thus most likely to be a source of poisoning. For convenience the poisonous plants are listed by families.

Acanthaceae. Only a relatively few plants of the Acanthaceae yield poisonous leaves, generally due to the presence of alkaloids. These include *Jacobinia coccinea* Hiern, and *Thunbergia alata* Boj., the clock vine. Nevertheless, leaves of the latter are reported to be edible.

Amaranthaceae. A few common herbs which are eaten as green leaves, including of the genera *Amaranthus*, *Celosia*, and *Gomphrena* have been reported to contain small, and probably insignificant quantities of alkaloids. However, the poisonous substance in livestock loss has been excessive quantities of nitrate.

Amaryllidaceae. Tropical lilies, as in the case of temperate zone species, frequently are poisonous. The alkaloids or other substances are usually present chiefly in the bulb, as in the case of *Crinum* and *Hymenocallis*, but the leaves may contain small quantities. All lily leaves should be thought of as potentially poisonous.

Anacardiaceae. The family of the cashew is noted for its poisonous substance which stimulate strong rashes in some and not in other persons. In the tropics of the Americas an insidious group of plants of the genus *Comocladia* (*C. dodonea* (L) Urban, *C. glabra* (Schultes) Spreng) irritate the skin in much the same manner as do poison oak and poison ivy of the temperate zone. Unfortunately, the irritation appears several days after touching the plant, and therefore a person walking through dense brush can accumulate in a short time what will explode into a violent irritation later. The irritating principal can be carried through the body and can result in eruptions far from the area of contact.

The common mango, *Mangifera indica* L., is both a contact and stomach poison in the case of many persons. Although it is consumption of the fruit that is generally considered the source of inflammation, contact with the leaves, and especially the sap of the tree or unripe fruit can be equally harmful. In spite of this the young leaves are sometimes eaten.

Annonaceae. Leaves of several common species of *Annona*, including *A. squamosa*, the sugar apple, and *A. reticulata*, the custard apple, contain alkaloids and are potentially poisonous. The leaves of some *Polyalthias*, ornamentals grown for their attractive foliage, are also poisonous.

Apocynaceae. This widespread family is well known throughout the tropics for its poisonous plants. The sap of the lovely ornamental shrub *Allamanda cathartica* L., is dangerously purgative if taken in quantity. Leaves of the edible fruit bearing *Carissa* species contain alkaloids. The garden oleander, *Nerium oleander* L. (Fig. 45) and some of its tropical relatives (*Thevetia* sps.) contain dangerous amounts of toxic glycosides. It is said that a single leaf of oleander is sufficient to kill a person. Poisoning may result from the routine handling and pruning of these widespread plants, or from inhalation of the smoke when the vegetative parts are burned. It is a dangerous plant for children, and has only a doubtful place in the home garden. The leaves of the frangipanis (*Plumeria* sp.) contain unknown alkaloids.

As reported earlier, the young leaves of *Catharanthus roseus* (L.) G. Don are sometimes edible. The older leaves of this and related species contain alkaloids. Leaves and roots are used in folk medicine to induce vomiting, for

Figure 45.—*Nerium oleander*, one of the most dangerous of garden shrubs.

their purging effects, or for the treatment of worms.

Araceae. The aroids are obnoxious chiefly for the crystals of calcium oxalate which sting the skin or the roof of the mouth when ingested. Practically all species contain some such crystals under some circumstances, and appropriate cooking methods are therefore required. Other species contain alkaloids in their leaves.

The common *Diffenbachia*, used as an attractive broad-leaved ornamental plant, has an interesting poisoning effect thought to be due to toxin as well as calcium oxalate crystals. After ingestion of juice or vegetative plant parts, the throat swells, preventing speech. The poisoning is usually temporary, but fatalities have been reported in Brazil.

Asclepiadaceae. The milkweeds, *Asclepias* sps., of the temperate zones and the tropics are usually recognized as hazards to grazing animals. All parts of mature plants contain a poisonous resinoid, and glycosides and alkaloids are sometimes found. Symptoms include apathy, loss of muscular control, rapid pulse, and labored respiration. Young leaves of broad leaved but not narrow-leaved species are sometimes cooked and eaten.

The giant milkweed, *Calotropis procera* (Ait) R. Br., very common in the tropics is also toxic, such that the juice from the plant was used in arrow poisons and acts as a depilatory. A glycoside of the alkaloid calotropin and a cardiac glycoside have been reported to be the poisons. They stimulate the heart excessively and can kill in small doses very rapidly.

Cryptostegia grandiflora, the rubber vine, (Fig. 46), is a very attractive shrub widely planted for its large lovely flowers, and for its adaptability to dry areas. The milky sap of the leaf or stem contains a toxic glycoside that produces an irritation of the skin, or if taken internally, a severe diarrhea and heart failure. Teas prepared from the leaves have proved fatal. Poisoning often occurs when the plants are routinely pruned. This species thus hardly merits a place in the home garden.

Compositae. Among the composites there are many species with alkaloids or other poisonous principles in the leaves, including species from genera of which the leaves are eaten. These include *Artemisia*, *Senecio*, *Vernonia*, and *Xanthium*. Frequently unknown, the alkaloids are often not present in harmful concentrations.

Euphorbiaceae. This is a family usually recognized for its poisonous plants. The substances, usually alkaloids of the milky sap, are often poisonous on contact, and may be harmless after cooking. Individuals vary in sensitivity to poisoning by Euphorbiaceous species.

Aleurites species, especial *A. fordii* Hemsl. (Fig. 47), the source of tung oil, are highly toxic due to the presence of a saponin and an unidentified poisonous substance. These trees are sometimes grown as ornamentals for their large, attractive leaves. Symptoms of poisoning include loss of appetite, depression, and hemmorrhagic diarrhea.

The leaves of most species of *Croton*, common, somewhat woody weeds of the tropics, contain a purgative oil of formidable strength. Especially well known in dry places, Crotons are seldom taken as food or feed, but because of their ubiquitous nature, constitute a constant hazard.

In another portion of this text the young leaves of *Euphorbia pulcherrima* Willd. are described as edible. Nevertheless, many persons are susceptible

Figure 46.—Leaf and flower of *Cryptostegia grandiflora*, erroneously called the purple allamanda.

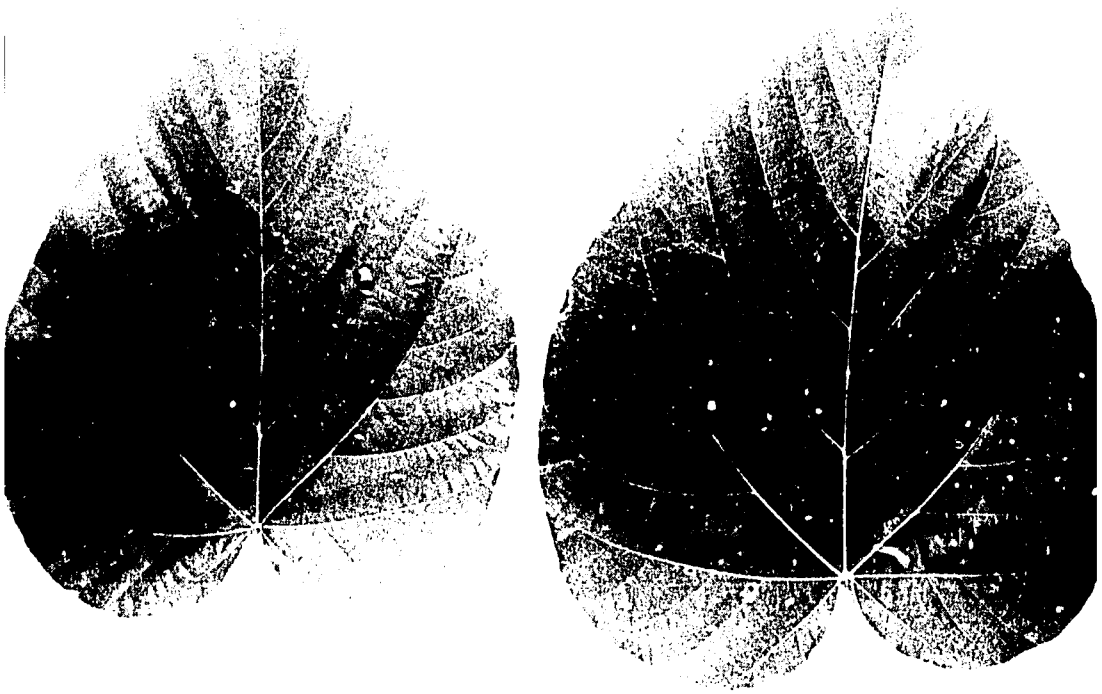

Figure 47.—*Aleurites fordii*, tung, the source of oil and poisonous leaves.

to the milky sap of the leaves or stem, which causes a wicked irritation of the skin. This may crack open and become infected. Pruning the plants in the garden is a frequent cause of poisoning. Poisoning of children from eating the leaves has been reported. Strong stomach pains are a symptom. A dilemma thus exists, for young leaves are edible cooked.

Most species of *Jatropha* are poisonous due to purgative oil and a still unidentified substance. Boiling is said to render the poisonous seeds harmless.

The very succulent species of *Euphorbia* often leafless or with leaves during only part of their life cycle also contain a toxic milky sap that is very irritating to some humans. Among the common plants causing poisoning is *E. tirucalli* L., the pencil tree.

The famous machineel, *Hippomane mancinella* L., tree of the Caribbean is well appreciated in literature or by those who have come in contact with it. An attractive tree of the beaches and of dry areas, an apple like fruit is produced, which has often been consumed with fatal results. The sap of the tree is a very strong irritant of the skin, and poisoning has been reported from resting under the boughs. Some persons are more susceptible than others. One of the poisons is an alkaloid thought to be physostigmine, but other substances are not yet identified.

The sandbox tree, *Hura crepitans* L., is planted throughout the tropics for its atrractive form, or used as a living fence post. It is the sap of the species, which can be obtained from the stems or leaves, which contains an unidentified emetic and cathartic substance, and another poison. The seeds are particularly poisonous.

The castor bean, *Ricinus communis* L. is often seen in gardens grown as an ornamental. In spite of the fact that the young leaves are cooked and eaten, mature leaves as well as seeds contain alkaloids associated with the protein. Symptoms of poisoning include nausea, vomiting, pains of the abdomen, feverish skin, accelerated pulse, and blurred vision. Most poisoning occurs from eating the seed, but all parts contain some poison.

Labiatae. The mint family includes many species that contain poisonous volatile oils. An attractive mint like weed characterized by whorls of small flowers at the nodes, *Leonotis nepetaefolia* (L.) R. Br., is often a source of irritation to persons allergic to it. The burning irritation is associated either with the fine hairs of the leaf or with the pollen. Nevertheless, the leaves are often fed to rabbits and may not be toxic to humans.

Leguminosae. Perhaps no family contains as many poisonous species as the legume family. On the other hand, few families have given to humanity so many edible species. Poisonous principals of the legumes are principally the alkaloids, of which a wide variety occur, and also toxalbumins, and toxic metals. Genera with poisonous leaves include *Acacia*, *Albizzia*, *Cassia*, *Crotalaria*, *Erythrina*, *Genista*, *Lupinus*, *Pithecelobium*, *Sesbania*, *Sophora*, and *Tephrosia*.

Wild coffea, *Cassia occidentalis* L., is one of those ubiquitous small trees that are useful and poisonous at the same time. The seeds are weakly poisonous until roasted, when they are used as a coffee substitute. The leaves used in folk medicine, contain lesser quantities of the substance chrysarobin. *Cassia siamea* Lam, very common in the tropics, has foliage especially attractive to pigs, and fatal. The poisonous substance is an alkaloid. *Cassia* species

in general tend to contain alkaloids and can be considered a dangerous group.

Species of *Crotalaria* (Fig. 48), attractive legumes of the tropics, contain the alkaloid crotaline, or related substances. Sometimes grown in the garden for their attractive yellow flowers or inflated pods, Crotalarias should be considered a risk wherever children have access to them. Poisoning can be rapid or very slow. Symptoms include bleeding of the stomach. Leaves are less toxic than the deadly seeds.

Meliaceae. The china berry, *Melia azedarach* L., a beautiful ornamental tree now distributed through the tropics, is generally recognized as poisonous. The fruits are well liked by pigs and have caused serious poisoning. Other domestic animals are less susceptible. Human poisoning from eating the leaves is not common. The leaves contain an alkaloid, paraisine, distinct from that of the fruits, azaridine.

Solanaceae. This extremely common family contains a number of strongly poisonous species, and the leaves of almost all species can be considered dangerous. Particularly dangerous genera in the tropics are *Datura*, *Nicotiana*, *Physalis*, and especially *Solanum*. The poisonous substances are alkaloids of several classes, including glycoalkaloids with a steroid nucleus, a useful raw material for the synthesis of steroidal drugs and birth-control pills.

Leaves of the genus *Datura*, including jimson weed are extremely poisonous, and these plants should be kept out of the garden. A series of alkaloids increase the pulse and rate of respiration. Diarrhea, dilation of the pupils of the eyes, and rigidity of the body are common symptoms. Children have been killed by chewing or sucking the attractive flowers.

Verbenaceae. The Lantanas of the tropics, familiar weeds of neglected areas, are often taken into cultivation for their attractive umbels of bicolored flowers (Fig. 49). The leaves are poisonous due to the presence of alkaloids, in some cases lantanine. However, amounts of leaves insufficient to kill may have a photosensitizing effect. Light skin exposed to the sun becomes yellow, swollen, hard, and painful. The fruits may also be poisonous.

A few other common plants with poisonous leaves are listed in Table 12. Full coverage of poisonous plants of the United States is given in Kingsbury's book (1968). Some tropical species are reviewed by Oakes (1962). No complete coverage of the poisonous plants of the tropics is available, but many more plants are believed to be poisonous.

Experimenting with the edible properties of leaves

Knowledge of the edible and poisonous properties of leaves must have developed slowly over a long period of time. Since cases of fatal poisoning from eating leaves continues, it is obvious that experimentation has not ceased and that eating leaves can be dangerous. Therefore, any person interested in trying new leaves as food should be fully aware of the dangers, and should practice extreme caution. Some very important points include:

1. Know the species before attempting to eat the leaves. Consult authorities if possible, and become a reasonable expert on the plant involved before trying it out.

Figure 48.--*Crotalaria retura* L.: its colorful flowers and poisonous leaves.

Figure 49.–*Lantana camara* with its colorful flowers and fruits.

2. Avoid leaves of plants with milky sap, unless absolutely identified as safe.

3. Do not eat new leaves raw. Cook them, and throw away the cooking water.

4. If cooked leaves are bitter, avoid them.

5. If leaves are very sour they may contain excessive amounts of oxalic acid. Avoid eating too much of them.

6. Try out new but identified leaves in very small amounts and progress gradually towards the use of larger amounts.

7. Leave experimentation with unknown leaves to the laboratory of experts.

The problem of identifying new edible leaves in the laboratory is a difficult one that will not be solved easily. Species that bear leaves that are sufficiently succulent can be tested for the presence of alkaloids and the more obvious classes of poisonous substances. After that small animal trials can be used to establish edibility. These are not simple. The long-term effects of an item of the diet can only be solved by laborious experimentation. On the other hand, if deleterious effects are found, isolation and identification of the poisonous substance may need years of study.

Thus, we suggest to the lover of green leaves; "Caution is always appropriate; experimentation is dangerous."

Table 12.—Other common plants with poisonous leaves.

Family	Species	Common name	Type of poison
Sapotaceae	*Achras sapota* L.	Sapodilla	Alkaloid
Rosaceae	*Eriobotrya japonica* Lindl.	Loquat	Cyanogenic glycoside
Myrtaceae	*Eugenia jambos* L.	Rose apple	Cyanogenic glycoside
Winteraceae	*Illicium anisatum*	Shikimi tree	Alkaloid
Proteaceae	*Macadamia ternifolia* F. Muell.	Macadamia nut	Cyanogenic glycoside
Leguminosae	*Pachyrrhizus erosus* Urban	Yam bean	Alkaloid
Passifloraceae	*Passiflora quadrangularis* L.	Granadilla	Cyanogenic glycoside
Graminae	*Sorghum vulgare* Pers.	Sorghum	Cyanogenic glycoside
Apocynaceae	*Strophanthus* sps.	Strophanthus	Alkaloid
Liliaceae	*Gloriosa superba* L.	Climbing lily	Alkaloids
Saxifragaceae	*Hydrangea macrophylla* Ser.	Hydrangea	Cyanogenic glycoside
Leguminosae	*Acacia berlandieri*	Guajillo	Polypeptide

CHAPTER X

Culture and Care of Green-Leaved Vegetables

All green-leaved vegetables bear both edible and non-edible leaves. The edible leaves are invariably the young and succulent leaves near the tip of the shoot. Older leaves tend to be tough and fibrous or may accumulate bitter substances. Therefore, the appropriate cultural conditions are those that stimulate succulent growth or maximize the production of succulent leaves. These conditions will not be the same for all species that bear edible green leaves. Local experimentation in production methods will always be necessary.

Climate

Climate is the average condition prevailing in an area, as affected by rainfall, winds, light intensity, atmospheric pressure, and annual changes. Weather, then, is the daily variation in the climate. Although climate can seldom be changed to meet the needs of the gardener, the climate as well as the weather influence the success of green-leaved vegetables. Those aspects of the climate of most importance are temperature, light, and water.

In discussing climate one must always distinguish between macro- and microclimate. Whereas any area can be characterized by its climate in general, nevertheless, local influences, many under man's control, can effectively modify the effective climate in a given area. Small pockets where local influences prevail are said to have particular microclimates. The gardener, once aware of the climatic needs of his plants, can modify his treatments to approximate optimum conditions.

Tropical climates are varied. Within the areas of the tropics and subtropics rainfall varies from 200 to 10,000 mm per year. Rainfall is seldom uniformly distributed, however, so that seasons of different rainfall can be distinguished (wet and dry seasons). Temperature varies from the hottest measured to near the lowest (in tropical alpine areas). Light intensity varies among macro- as well as microclimates due to local conditions including latitude and atmospheric conditions. Only day length, directly related to latitude, cannot reach extremes. Because of the wide range of geographic situations in the tropics, suitable climates occur for almost all green-leaved vegetables, although the growth patterns of typical summer vegetables of the temperate zone may be adversely affected by the relatively short summer days of the tropics.

Temperature in the tropics is closely associated with latitude, altitude, atmospheric conditions, and proximity of large bodies of water. Low temperatures limit the growth of green-leaved vegetables in very few locations. Indeed, some of the cooler climates of the tropics are optimal for temperate zone leafy greens, especially spinach, brussels sprouts, but also broccoli, cabbage, lettuce, etc. High temperatures, however, frequently inhibit plant growth especially when associated with winds and inadequate moisture. High daytime temperatures can be modified with light shading. Although this can be accomplished with relatively open-canopied trees, such as guama (*Inga*

vera) and mother-of-cacao (*Gliricidium sepium*), these tend to compete with garden plants because of their ramified root systems. Shelters of palm leaves, branches, or saran cloth (Fig. 50) can be constructed cheaply and in the case of the latter, are durable. The modified climate below such shelters can be further changed by irrigation during the hottest weather.

The effects of wind on local temperature conditions can be modified by windbreaks. These need to be set to the windward side of the garden area and should be of tall, relatively narrow materials. Some plants (*Panax* species, Fig. 51) provide both attractive windbreaks as well as ornamental hedges. The effective distance of a windbreak, however, is usually calculated at only 2 1/2 times its height. This distance is multiplied when the windbreak is used in conjunction with a shade producing shelter.

Light intensity is seldom a limiting factor in the tropics. This may not be the case in very cloudy climates or during intense rainy seasons. The modification of the climate to increase light intensity is seldom necessary. On the other hand, light intensity may be reduced, as needed, by appropriate shading.

Effects of day length are particularly marked in the tropics. Contrary to popular belief, tropical plants are more, not less sensitive to day lengths, and in fact their vegetative versus flowering phases may be controlled by differences in day length of a half-hour or less. Most of the green amaranth varieties do not produce well during short days. They begin to flower when the plants are too small for good leaf production. This response to short days can often be corrected by additional illumination. (Fig. 52). Such light need not be intense nor of long duration, but its effects on plant growth may be extreme.

Moisture

Water is necessary, of course, for plant growth. Two classes of problems can be distinguished associated with water, problems of scarcity of water, and problems of excess water. For gardening of green-leaved vegetables, adequate water is a necessity. Without water the desired succulence of the foliage cannot be obtained or maintained. Growth rates, furthermore, are reduced. The amount of water needed by the plant cannot be judged only by the wetness of the surface of the ground. A dry surface can occur naturally, while still large quantities of water remain available to the plant. On the other hand, wilting suggests a condition of dryness that has already gone too far. Established plantings should not be permitted to dry to the point of wilting, for even if the plants recover after irrigation, their growth has been impeded.

Excess moisture on the other hand, is the cause of many problems. Moisture on the leaves promotes fungal growth. Excess water in the soil promotes disease. Water logging impedes the respiration of roots and can even lead to wilting. In addition, heavy rains can injure plants, even destroying young seedlings.

Excess rainfall and dew are difficult to control. Nevertheless, if such conditions are expected the gardener can partially modify conditions in order to minimize deleterious effects. Shelters constructed for shading also reduce the force of heavy rains. Planting on ridges with adequate drainage ditches to carry off excess water reduces water logging and disease. If night dews are a problem, orienting the garden with respect to night breezes may help main-

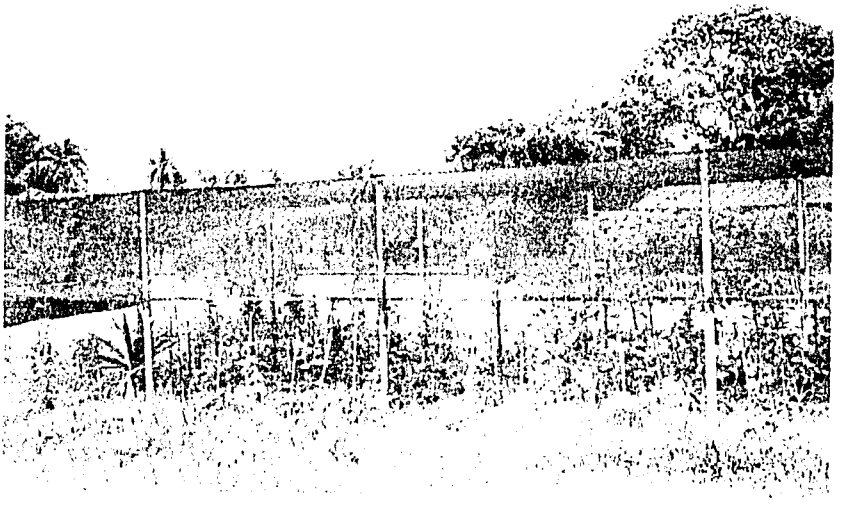

Figure 50.– A saran cloth shelter used to reduce light intensity and temperature.

Figure 51. – A *Panax* hedge which reduces wind under the glass roof.

Figure 52. A field illuminated with light at night to avoid short day effects.

tain drier conditions.

The wise gardener studies local climatic conditions and modifies them to achieve desired effects. Since green-leaved vegetables also differ, some understanding of the specific needs of the various species is also desirable so that cultural practices can be controlled.

Soils

Tropical soils vary tremendously in all important characteristics. Although exact recommendations cannot be given in advance of the study of particular soils and their characteristics, the choice of soil for the garden is extremely important in determining its success. However, when soils are not perfectly suitable they often can be made productive with proper management.

Clay soils (those containing principally very fine particles) are sometimes quite fertile, but their heavy textures impede drainage and proper aeration. Furthermore, such soils are often hard to manage. Plowing or soil preparation when the soil is too wet may lead to the formation of durable clods. When finely broken up, however, such soils can be productive. Structure of the soil can be improved by the addition of organic material. Ridging the soil improves drainage and aeration.

Sandy soils, on the other hand, are often lacking in sufficient nutrients. In addition, although aeration can be excellent, drainage is often excessive. Such soils need organic materials to improve the retention of water and nutrients. Nematodes are often a problem on sandy soils. These, by their injury to the roots, reduce vigor and yield.

The ideal soil, a loam, consists of mixtures of particles of different sizes, large (sand), small (clay), and intermediate (silt). Such a soil will have good drainage and yet retain sufficient air, water and nutrients for good plant growth.

The hydrogen ion content (pH) of the soil exerts a great influence on the growth of plants. If the soil is too acid (low pH) or too alkaline (high pH) the retrieval by the plant of essential minerals will be impeded. A pH of 6.0-7.0 is most desirable for most green-leaved vegetables, but tolerance to both high and low pH varies. Low pH's can be corrected by addition of lime (calcium carbonate) to the soil in fairly large quantities (5 tons/hectare). This may be supplied in many fashions, including burned lime, hydrated lime, crushed limestone, shell, etc. Once applied the lime is not immediately effective. Benefits increase with time.

High pH is corrected by the addition of sulphur, usually in the form of powder, at average rates of 1000 kg/hectare or more. Tables have been published for calculating the appropriate quantity of lime or sulphur for different soils, depending on the pH found and the correction desired (Knott, 1957). Without adequate tests of pH and study of the soil type, additives will not usually be used in correct proportions.

Organic materials in the soil improve the structure, and lead to good drainage, aeration, and nurtrient availability. However, the material should be well-rotted or it will tend to tie up the nitrogen available in the soil and thus deprive the growing plants of this essential element. In contrast to mineral fertilizer, organic materials release nutrients into the soil for a relatively

long, continuous period. Such amendments are often preferred over mineral fertilizers, but the latter are also necessary.

Mineral Fertilization

Tropical soils are often badly leached by heavy rainfalls, and are not productive unless appropriately treated. Although the addition of organic material is one of the surest ways to improve fertility of a soil, especially on the scale of the home garden, such materials are often not available. Mineral fertilizers are desirable in such cases, but may also supplement the addition of organic materials to the soil.

For most crop plants, and especially for green-leaved vegetables, nitrogen is the most important element in a mineral fertilizer. Nitrogen is an important building block of amino acids, proteins, and other plant constituents. Nitrogen promotes vegetative growth in contrast to root growth. For green-leaved vegetables, nitrogen darkens the green color, and improves succulence. Nitrogen, supplied to the soil chiefly by decay of organic materials, and by bacterial fixation, iseasily leached from the soil by rains. It is the element most likely to be lacking sometime during the course of the growth of the plant, and the single element most likely to stimulate growth of green-leaved vegetables. Lack of nitrogen leads to general yellowing of the foliage (Fig. 53). The mineral fertilizer used for green-leaved vegetables should be fairly high in nitrogen.

Phosphorous is also a very important element in nutrition of green-leaved plants. It is a component of the natural buffer system of plants, and is extremely important in energy transfer. It is found in many important compounds. Phosphorous in the soil is formed by the breakdown of normal minerals and is often relatively plentiful. Nevertheless, phosphorous often occurs in insoluble forms that are of no benefit to the plant. It may not be lacking except when intense cultivation is practiced. Phosphorous is not leached rapidly from the soil and the effect of application may last for several seasons. Phosphorous deficiency is difficult to diagnose. Symptoms often include unnaturally dark green leaves and reddish tinges of leaves and stems. The mineral fertilizer used for green-leaved vegetables need have only moderate amounts of phosphorous.

Potassium is another element of much importance to growing plants. It is associated with carbohydrate and protein synthesis and with many growth processes. Potassium in the soil comes from the weathering of common minerals. Nevertheless, in highly leached soils potassium is frequently limiting. Potassium deficiency is usually seen in terms of local symptoms, including mottling, chlorosis, and necrosis, especially near the margins and tips of the leaf. The amount of potassium suitable for green-leaved vegetables can hardly be predicted in advance. Without specific knowledge of needs, a fertilizer for green-leaved vegetables should contain moderate to high amounts of potassium.

Nitrogen, phosphorous and potassium are the most necessary elements of a mineral fertilizer. When all three are present, the fertilizer mixture is said to be balanced. When a fertilizer is purchased the percentage of these elements in the mixture is indicated on the bag by numbers such as 12-5-10 (12 percent nitrogen, 5 percent phosphorous, 10 percent potassium). However,

Figure 53.—Plants showing symptoms of nitrogen deficiency (right) compared to healthy plants of the same age (left).

other elements are frequently lacking and may limit production in specific soils. These include calcium, magnesium, sulfur, iron, manganese, and others. When it is possible to buy fertilizer mixtures with added "minor elements", these generally provide an insurance against shortages. For the home gardener it is usually impractical to determine the special needs for these minerals in small garden plots.

Balanced mineral fertilizer can be applied before seeding at the rate of a handful per meter of row. The fertilizer can be buried under the planting ridge. Additional nitrogen can be applied after seedlings are established, dissolved in water or applied along the ridge but not in direct contact with the plant.

The entire subject of soils and mineral fertilization is beyond the scope of this book. The serious student must look elsewhere.

Preparation of Soil and Planting

Soil preparation for green-leaved vegetables is no different from that for tropical vegetables in general. Excess vegetation must be cleared from the area. Discarded plant remains can be composted for later use in the garden. The soil must be loosened or turned over with fork, shovel, or plow. At this stage lime can be added to improve the texture and fertility of the soil. If the land can be left alone for several weeks and then turned again, many of the weed seeds will have germinated and will be eliminated. Large lumps of soil should be broken up to prevent the formation of hard troublesome clods.

The soil should then be formed into ridges or beds to permit drainage (Fig. 54). Mineral fertilizers can be added at this time, buried below the furrow if desired. The beds should be raked smooth leaving finely divided soil near the surface.

Tropical greens are often planted from cuttings. Although some such as cassava and sweetpotato, are planted directly in the field, it is usually more satisfactory to root cuttings first in moist sand before field planting. Large seeds can be planted directly in the garden but small seeds will germinate better in boxes or pots of finely sieved soil (Fig. 55). This suggests the desirability of a nursery area in the garden where small plants can be produced under suitable conditions.

A useful technique in establishing the garden is to cover the prepared area with a thin black plastic sheet (Fig. 56). The cloth can be weighted in the furrows or drainage ditches. To permit the penetration of water, holes or slits can be cut rapidly with hoe or machete. Seeds or seedlings are then planted directly through holes cut in the plastic. This technique results in very satisfactory weed control.

Care and Harvest

Once planted, all tropical greens are subject to pests and disease. It is often difficult to control these conditions in a small garden, and methodology is also well beyond the scope of this presentation. Particular problems encountered with some of these species are mentioned in the descriptions of the species.

Figure 54. Garden beds planted with many green-leaved vegetables.

Figure 55.—Seedling flats of green-leaved vegetables.

Figure 56.—Tahitian taro growing in a bed covered with plastic mulch.

Treatment of the garden, with ammonium sulphate, about 1 kg. per 35 meters of row, will help maintain the plants in succulent condition.

Many green vegetables can be harvested many times during their life cycle. Although the youngest leaves are usually the most tender, and in some cases, the most free of obnoxious or irritating principles, the older leaves sometimes have stronger flavors which appeal to the more initiated tastes. With any species the first few harvests will rapidly demonstrate the qualities of the younger versus older leaves. When older leaves can be eaten, it is preferable to do so, for the younger leaves are necessary for the continued growth of the plant. A system of harvesting older but not overmature leaves will generally permit the most rapid recovery of the plant, and the rapid production of a new crop. Nevertheless, each species differs and must be treated separately.

It must be emphasized here that details of culture have not been worked out for many of the green leaf crops mentioned herein. A certain amount of experimentation is always necessary and desirable. The alert gardener will rapidly accustom himself to the requirements of the particular crop.

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APPENDIX

A List of Tropical Plants With Edible Green Leaves

ACANTHACEAE

Species	Source	Plant type
Acanthus montanus T. And.	Congo	Shrub
Afromendoncie gilgiana Lind.	Congo	Herb
Asystasia gangetica T. And.	Pantropical	Herb
A. schimperi T. And.	Old world tropics	Herb
A. vogeliana Nees.	Old world tropics	Herb
Barleria opaca Nees.	Africa	Shrub
B. talbotii S. Moore	Africa	Shrub
Brillantaisia alata Anders.	Congo	Herb
Dicliptera chinensis Juss.	Southeast Asia	Herb
D. papuana Warb.	New Guinea	Herb
D. umbellata Juss.	Africa	Herb
Dipteracanthus longifolia Hochs.	Pantropical	Herb
Eremomastax polysperma (Benth.) Dandy	Central Africa	Shrub
Hygrophila auriculata Heyne	Africa	Herb
H. quadrivalvis Nees.	Africa, Southeast Asia	Herb
H. salicifolia Nees.	India	Herb
H. serpyllum T. And.	India	Herb
H. thonneri de Wild.	Congo	Herb
Hippoestes verticillaris R. Br.	Africa	Herb
Justicia flava Vahl.	West Africa	Herb
J. galeopsis T. And.	Southeast Asia	Herb
J. glabra Koen. ex Roxb.	West Africa	Herb
J. insularis T. And.	West Africa	Herb
J. melampyrum S. Moore	West Africa	Herb
J. metammensis Oliv.	South Africa	Herb
J. pectoralis Jacq.	West Africa	Herb
J. procumbens L.	India	Herb
J. quinque-angularis Koenig	India	Herb
J. rostellaria Lindau	Mexico	Herb
Lankesteria barteri Hook. f.	Congo	Herb
Nelsonia brunelloides O.K.	Congo	Herb

Species	Source	Plant type
Pseuderanthemum bicolor Radlk.	Philippines	Shrub
P. racemosum Radlk.	Southeast Asia	Shrub
P. reticulatum Radlk.	Philippines	Shrub
P. tunicatum Milne-Redh.	Gabon	Shrub
Rhinacanthus calcaratus Nees.	Burma	Herb
R. nasutus Kurz.	Southeast Asia	Herb
Rungia grandis T. And.	Congo	Herb
R. klossii S. Moore	Nigeria (highlands)	Herb
Staurogyne elongata O. Ktze.	Southeast Asia	Herb
Thunbergia alata L.	Caribbean	Vine
T. bogoriensis de Wild.	Congo	Vine
T. lancifolia T. And.	Africa	Vine
T. oblongifolia Olr.	Africa	Vine

AIZOACEAE

Aizoon canariense L.	Africa	Herb
Aptenia cordifolia (L.) Schwantes	South Africa	Herb
Cryophytum aitonis (Jacq.) N.E. Br.	South Africa	Herb
C. crystallinum (L.) N.E. Br.	Canary Islands Africa	Herb
Ginus lotoides Loefl.	Africa	Herb
Lithops hookeri (A. Berger) Schwantes	S. Africa	Herb
Mesembryanthemum angulatum Thunb.	Congo	Herb
M. cordifolium L. f.	South Africa	Herb
M. crystallinum L.	India	Herb
Mollugo nudicaulis Lam.	Congo	Herb
M. oppositifolia L.	Southeast Asia	Herb
M. pentaphylla L.	Southeast Asia	Herb
Sesuvium portulacastrum L.	Pantropical	Herb
Tetragonia decumbens Mill.	Southern Africa	Herb
T. expansa Miers	New Zealand	Herb
T. fruticosa L.	Southern Africa	Herb
Trianthema pentandra T.		Herb
T. portulacastrum L.	Philippines	Herb

ALISMATACEAE

Species	Source	Plant type
Sagittaria sagittifolia L.	Eastern Asia	Herb

AMARANTHACEAE

Achyranthes aspera L.	Pantropical	Herb
Acnida cuspidata Bert.	America	Herb
Aerva javanica Juss.	West Africa, India	Herb
A. lanata Juss.	West, East Africa	Herb
A. tomentosa Forsk.	Africa	Herb
Allmania albida R. Br.	Southeast Asia	Herb
A. nodiflora R. Br.	Ceylon, Philippines	Herb
Alternanthera ficoidea R. Br.	Tropical America, West Africa	Herb
A. maritima St. Hill	Tropical America, West Africa	Herb
A. nodiflora R. Br.		Herb
A. triandra Lam.	Tropical America, West Africa	Herb
A. versicolor L.	Tropical America, West Africa	Herb
Amaranthus blitum L.	Worldwide	Herb
A. caudatus L.	Pantropical	Herb
A. chlorostachys Miq.	Worldwide	Herb
A. cruentus L.	Worldwide	Herb
A. dubius Thill	Worldwide	Herb
A. frumentaceus L.	Worldwide	Herb
A. gangeticus L.	Pantropical	Herb
A. gracilis Desf.	Worldwide	Herb
A. hybridus L. sp. cruentus (L.) Thell.	Congo	Herb
A. hybridus L. sp. hybridus	East Africa, Trop. America	Herb
A. lividus L.	East Africa	Herb
A. mangostanus L.		Herb
A. melancholicus L.	Tropics	Herb
A. oleraceus L.		Herb
A. paniculatus L.	Trop. America	Herb
A. patulus Bertol.		Herb
A. polygamus L.		Herb
A. polygonoides L.		Herb
A. spinosus L.	Worldwide	Herb
A. thunbergii Miq.	South Africa, Congo	Herb
A. tricolor L.	Pantropical	Herb
A. viridis L.	Southeast Asia, Africa	Herb

Species	Source	Plant type
Celosia argentea L.	India	Herb
C. bonnivairii Schinz.	Congo	Herb
C. cristata L.	Worldwide	Herb
C. laxa Schum. et Thonn.	Tropical Africa	Herb
C. trigyna L.	Tropical Africa	Herb
Cyathula prostrata Bl.	Congo	Herb
Deeringia amaranthoides Merr.	Southeast Asia	Shrub
Digeria arnensis Forsk.	India, Africa	Herb
Gomphrena globosa L.	Pantropical	Herb
Pandiaka heudelotii (Moq.) Hook. f.	Cameroun	Herb
Philoxarus vermicularis R. Br.	Pantropical	Herb
Sericostachys scandens Gilq. et Lepr.	Congo	Herb

AMARYLLIDACEAE

Agave cantala Roxb.	Indonesia	Herb
A. sisalana Perr.	Pantropical	Herb
Cyrtanthus bicolor R. A. Dyer	Africa	Herb
Pancratium trianthum Herb.	Africa	Herb

AMPELIDACEAE

Vitis quadrangularis Wall	India	Vine

ANACARDIACEAE

Anacardium occidentale L.	Indonesia	Tree
Bouea macrophylla Griff.	Malaysia, Indonesia	Tree
B. oppositifolia Misn.	Thailand	Tree
Dracontomelon dao (Blanco) Merr.	Malaysia to Fiji	Tree
Gluta velutina Blume	Malaysia	Tree
Lannea acida A. Rich	Guinea coast	Tree
L. grandis Engl.	Indonesia	Tree
L. microcarpa Engl. et K. Krause	West Africa	Tree
L. oleosa A. Chev.	Dahomey	Tree
Mangifera caesia Jacq.	Indonesia	Tree
M. indica L.	Pantropical	Tree

Species	Source	Plant type
Pseudospondias microcarpum Engl.	Congo	Tree
Semecarpus cassuvium Roxb.	Indonesia	Tree
Spondias cytherea Sonn.	India	Tree
S. pinnata Kurz.	Philippines	Tree
S. purpurea L.	South America	Tree

ANNONACEAE

Annona muricata L.	Tropical America	Tree
Cleistopholis patens Engl. et Pzantl.	Africa	Tree
Enneastemon foliosus (Engl. et Diels) Robyns et Chesq.	Eq. Africa	Tree

APOCYNACEAE

Agonosma marginata G. Don.	Thailand	Vine
Alafia lucida Stapf.	Congo	Vine
Catharanthus roseus (L.) G. Don.	Congo	Herb
Cerbera manghas L.	Pantropical, Indonesia	Tree
Chilocarpus cantleyi King.	Southeast Asia	Vine
C. denudatus Bl.	Indonesia	Herb
Fernaldia pandurata R. E. Woodson	America	Herb
Isonema smeathmannii Roem et Schult.	Africa, Sierra Leone	Shrub
Lochnera pusilla K. Shum.	India	Herb
L. rosea L. f.	India	Herb
Pycnobotrya nitida Benth.	Congo	Herb
Vallaris heynii Spreng.	Thailand	Shrub

AQUIFOLIACEAE

Ilex paraguayensis St. Hil.	South America	Shrub
I. vomitoria Ait.	South America	Shrub

ARACEAE

Species	Source	Plant type
Aglasnema pictum Kunth	Malaysia, Southeast Asia	Herb
Alocasia indica Schott	East Asia	Herb
A. macrorrhiza Schott	India	Herb
Amorphophallus campanulatus Bl.	Philippines, Indonesia	Herb
A. rivieri var. konjac Engl.	China	Herb
A. schweinfurthii N.E. Br.	Sudan	Herb
Anadendrum montanum Schott	Malaysia	Herb
Caladium bicolor Vent.	Pantropical	Herb
Colocasia esculenta Schott	Hawaii, Fiji, Southern Asia	Herb
C. gigantea Hook. f.	India	Herb
Cyrtosperma sp.	South Pacific	Herb
Lasia spinosa Thu.	Southeast Asia	Aquatic plant
Pistia stratiotes L.	Pantropical, Sudan, China	Aquatic plant
Rhaphidophora lobbii Schott	Malaysia	Vine
Schismatoglottis calyptrata Zoll. and Mor.	Southeast Asia	Herb
Spathiphyllum commutatum Schott	Southeast Asia	Herb
S. phrynifolium Schott	South America	Herb
Spathiphyllum sp.	Tropical America	Herb
Stylochiton hypogeum Lepr.	Africa	Herb
S. warneckii Engl.	Africa	Herb
Typhonicum trilobatum Schott	India, Ceylon	Herb
Xanthosoma alberttii	Tropics	Herb
X. brasiliense Engl.	Pantropical	Herb
X. caraca Koch. et Bouche	Venezuela	Herb
X. jacquini Schott	South & Central America	Herb
X. mafaffa Schott	South & Central America	Herb
X. violaceum Schott	Pantropical	Herb
Zantedeschia aethiopica Spreng.	Africa	Herb

ARALIACEAE

Aralia cordata Thunb.	Japan	Herb
Boerlagiodendron palmatum Harms.	Indonesia	Shrub

Species	Source	Plant type
Nothopanax fruticosum Miq.	Indonesia	Shrub
N. pinnatum Miq.	Indonesia	Shrub
N. scutellarium Merr.	Indonesia	Shrub
Nothopanax sp.	Indonesia	Shrub
Schefflera aromatica Harms.	Southeast Asia	Shrub
Trevesia cheirantha Ridl.	Malay Peninsula	Shrub
T. sundaica Miq.	Dutch Indies	Shrub

ASCLEPIADACEAE

Asclepias affinis de Wild.	Africa	Herb
Boucerosia aucheriana Decne	India	Vine
Caralluma da siclii N.E. Brown	West Africa	Herb
C. europea N.E. Brown	North Africa	Herb
C. knobelii Phill.	South Africa	Herb
C. moureti A. Chev.	Africa	Herb
Ceropegia papillata N.E. Brown	Africa	Vine
C. stenantha K. Schum	Africa	Vine
Chlorocoda whitei Hook	Congo	Vine
Cynanchum ovalifolium Wight.	Indonesia	Herb
C. pauciflorum R. Br.	Ceylon	Vine
C. schistoglossum Schlecht.	Africa	Vine
C. tetrapterum (Turcz.)	East Africa	Vine
C. virens Steud	South Africa	Vine
Desdichium spp.	Polynesia	Vine
Dregia volubilis Benth	Ceylon	Herb
Duvalia polita N.E. Brown	South Africa	Herb
Ectadiopsis oblongifolia Schlecht.	Africa	Shrub
Finlaysonia maritima Backer	Indonesia	Vine
F. obovata Wall.	Southeast Asian Islands	Vine
Glossonema boveanum Decne	Africa	Herb
G. varians Benth.	India	Herb
Gomphocarpus albens Decne	Africa	Herb
Gymnema sylvestre R. Br.	Congo	Vine
G. syringefolium Boerl.	Malaysia	Vine
Holostemna annularis K. Schum.	India	Vine

Species	Source	Plant type
Leptadenia hastata Decne	Africa	Vine
L. pyrotechnica Decne	Africa, India	Vine
L. reticulata Wight et Arn.	India	Vine
Pentarrhinum insipidum E. Mey.	South Africa & Trop. Africa	Vine
Pergularia africana N.E. Br.	Congo	Herb
P. daemia Chior.	South Africa	Herb
P. extensa N.E. Br.	West Africa	Herb
Periploca aphylla Decne	Africa	Vine
Sarcostemna viminale R. Br.	Africa	Shrub
Secamone sp.	Africa	Herb
Stapelia kwebensis N.E. Br.	South Africa	Herb
T. cordata Merr.	Malaysia	Vine
T. minor Craib.	Thailand	Vine
Trichocaulon pillansii N.E. Br.	South Africa	Herb
Tylophora silvatica Decne	Central Africa	Herb
Xysmolobium umbellatum Ait.	South Africa	Herb
X. undulatum (L.) Ait.	South Africa	Herb

BALSAMINACEAE

Impatiens balsamina L.	Pantropical	Herb

BASELLACEAE

Basella alba L.	South America	Herb
B. rubra L.	South America	Herb

BATIDACEAE

Batis maritima L.	Pantropical	Herb

BEGONIACEAE

Begonia hirtella Link	Gabon	Herb
B. katoensis Hay	Formosa	Herb
B. poggei Warb.	Congo	Herb
B. siriculata	Gabon	Herb
B. tuberosa Lan.	Southeast Asia	Herb

BIGNONIACEAE

Species	Source	Plant type
Adenocalymna alliaceum	South America	Herb
Antidesma bunius Spreng.	Southeast Asia	Tree
Oroxylum indicum Vent.	Southeast Asia	Tree
Radermachera fimbriata K. Schum.	Thailand	Tree

BIXACEAE

Cochlospermum tinctorium A. Rich	Africa	Tree

BOMBACACEAE

Adansonia digitata L.	Africa	Tree
A. grandidieri Baill.	Madagascar	Tree
A. madagascariense Baill.	Madagascar	Tree
A. Za Baill.	Madagascar	Tree
Bombax buonopozense P. Beauv.	Indonesia	Tree
B. malabarica D.C.	Indonesia	Tree
B. ungulicarpum Ulbr.	Southeast Asia	Tree
Ceiba guineensis (Thonn.) A. Chev.	Tropical Africa	Tree
C. pentandra Gaertn.	Pantropical	Tree
C. thonningii A. Chev.	Tropical Africa	Tree
Durio zibethinus Murr.	Southeast Asia	Tree
Pochota glabra (Pasq.) Bullock	Equatorial Africa	Tree

BORAGINACEAE

Anchusa sp.	North Africa	Shrub
Ansinckia lycopsioides Lehm.	California	Herb
Borago officinalis L.	North Africa	Herb
Cordia dichotoma Forst.	Indonesia	Tree
C. francisci Ten.	Near East	Tree
C. myxa L.	Near East	Tree
C. obliqua Willd	Near East	Tree
C. olitoria Blanco	Near East	Tree
Echium sp.	North Africa	
Ehretia microphylla Lam	Philippines	Shrub
E. orbicularis Hutch et Bruce	Africa	

Species	Source	Plant type
Tournefortia argentea L. f.	Indian Ocean	Tree
Trichodesma ceylanicum R. Br.	Africa	

BROMELIACEAE

Bromelia karatas L.	Central America	Herb
B. pinguin L.	Central America	Herb

BURSERACEAE

Commiphora sulcata Chiov.	Africa	Herb
Protium javanicum Burm. f.	Indonesia	Tree

BUTOMACEAE

Limnocharis flava Buch	Java, Malaysia	Aquatic plant
L. loanigensis	Africa	Aquatic plant

CACTACEAE

Myrtillocactus geometricans Cons.	America	Shrub
Nopalea coccinellifera Solms-Dyck	America	Shrub
Opuntia subulata Engelm.	America	Shrub
Peireskia aculeata Plum.	Pantropical	Vine
P. bleo DC.	Pantropical	Vine

CAMPANULACEAE

Centropogon surinamensis Presl.	South America, Africa	Shrub
Lobelia alsinoides Lam.	India	Herb
L. fervens Thumb.	Africa	Herb
L. filiformis Lam.	Africa	Herb
L. succulenta Bl.	Southeast Asia	Herb

Species	Source	Plant type
Pentaphragma begoniaefolium Wall.	Malaysia, Southeast Asia	Herb
Spenoclea zeylanica Gaertn	Tropics, Southeast Asia	Herb
Wahlenbergia androsacea A. DC.	South Africa	Herb
W. undulata A. DC.	South Africa	Herb

CAPPARIDACEAE

Boscia angustifolia A. Rich.	Africa	Herb
B. salicifolia Oliv.	Africa	Tree
B. senegalensis Lam.	Africa	Tree
Cadaba farinosa Forsk.	Sudan	Shrub
Capparis corymbosa Lam.	Africa	Shrub
C. decidua Edgew		Shrub
Cleome ciliata Schum. et Thoan.		Herb
C. gynandra L.	Malaysia	Herb
C. hirta Oliver	Africa	Herb
C. icosandra L.	Pantropical	Herb
C. monophylla L.	Africa	Herb
C. rutidosperma DC.	Tropical Africa	Herb
C. speciosa DC.	Mexico	Herb
C. strigosa Oliver	Tanzania	Herb
C. viscosa L.	El Salvador	Herb
Crataeva adansonii DC.	Southeast Asia	Tree
C. macrocarpa Kurz	Indochina, Southeast Asia	Shrub
C. nurvala Buch. Ham.	India, Burma	Tree
Clitandra lacourtiana De Wild.	Central Africa	Herb
Euadenia trifoliata Benth. et Hook.	Africa	Shrub
Gyandropsis gynandra (L.) Briq.	Indonesia	Herb
Maerua angolensis DC.	Nigeria	Tree
M. crassifolia Forsk.	Africa	Tree
M. oblongifolia (Forsk.) A. Rich.	N. Cameroun	Tree
Polanisia hirta Pax	Congo	Herb

CARICACEAE

Carica papaya L.	South America	Tree

CARYOPHYLLACEAE

Species	Source	Plant type
Silene aegyptiaca L.	Near East	Herb
S. vulgaris (Moench) Garcke	Algeria	Herb
Stellaria aquatica Cyr.	India	Herb
S. media Cyr.	Near East	Herb

CELASTRINACEAE

Salacia pynaertii de Wild.	Africa	Shrub

CHAILLETIACEAE

Dichapetalum spp.	Tropics	Shrub

CHENOPODIACEAE

Arthrocnemum indicum Moq. Del.	India	Herb
A. pachystachyum Bunge	India	Herb
Atriplex arenaria Nutt	Sandy beaches	Herb
A. crassifolia C.A. Mey.	India	Herb
A. halimus L.	Sahara	Herb
A. repens Roth	Ceylon	Herb
Beta vulgaris L. forma cicla	Pantropical	Beet
Boussaingaultia baselloides HBK	Ceylon	Herb
Chenopodium album L.	India	Herb
C. amaranticolor Coste et Beyn	Madagascar	Herb
C. ambrosioides L.	Philippines	Herb
C. berlandieri Miq.	Mexico	Herb
C. glaucum L.	South Africa	Herb
C. murale L.	Africa	Herb
C. nuttalliae Saff.	South America	Herb
C. quinoa Willd.	South America	Herb
Dondia linearis Millsp.	Beaches and salt marshes	Herb
Salicornia ambigua Michx.	Beaches and salt marshes	Herb
S. bigelonii Torr.	Beaches and salt marshes	Herb

Species	Source	Plant type
Spinacea oleracea L.	Pantropical	Herb
Suaeda maritima Dumont	Pantropical	Herb
S. nudiflora Moq.	India	Herb
Ullucus tuberosus Cald.	High Andes	Herb

COMBRETACEAE

Combretum micranthum G. Don.	Gabon	Shrub
C. mooreanum Exell.	Africa	Tree
C. paniculatum Vent.	Africa	Shrub
C. platyphyllum Hutch. et Dalz.	Africa	Shrub
C. racemosum P. Beauv.	Africa	Shrub
Guiera senegalensis J. F. Gmel.	Africa	Tree
Lumnitzera racemosa Willd.	Southeast Asia, Polynesia	Tree
Quisqualis indica L.	Southeast Asia	Vine

COMMELINACEAE

Aneilema dregeanum Kunth	Africa	Herb
A. malabaricum Merr.	Southeast Asia	Herb
A. nudiflorum R. Br.	Southeast Asia, Malaysia	Herb
A. spiratum R. Br.	Southeast Asia	Herb
Commelina benghalensis L.	Southeast Asia	Herb
C. claessinsii de Wild.	Congo	Herb
C. clavata C. B. Clarke	Ceylon	Herb
C. forskalei Vahl.	Africa	Herb
C. latifolia Hockst.	Africa	Herb
C. nudiflora L.	Southeast Asia	Herb
C. obliqua Ham.	Southeast Asia	Herb
C. zambezica DC.	Africa	Herb
Cyanotis cristata Roem. & Schultes	Southeast Asia	Herb
C. cristata G. Don	Southeast Asia	Herb
C. nodiflora Kunth	Africa	Herb
Floscopa schweinfurthii G. G. Cl.	Guinea Coast	Herb
Forrestia glabrata Hassk	Southeast Asia	Herb
F. marginata Hassk.	Southeast Asia	Herb
F. mollissima Kds.	Southeast Asia	Herb

COMPOSITAE

Species	Source	Plant type
Ambrosia maritima L.	Congo	Herb
Artemisia dracunculus L.	Caspian Sea region and Siberia	Herb
A. vulgaris L.	Europe and North America	Herb
Aster amellus L.	Near East	Herb
Atractylis gummifera L.	North Africa	Herb
Bidens bipinnata L.	Africa, Asia	Herb
B. chinensis Willd.	Africa, Asia	Herb
B. leucantha Willd.	Africa, Asia	Herb
B. pilosa L.	Africa, Asia	Herb
Blumea balsamifera DC.	SW China	Herb
B. chinensis A. DC.	China	Herb
B. lacera A. DC.	Old World Tropics	Herb
B. myriacephala DC.	Indochina	Herb
Carthamus tinctorius L.	Subtropics	Herb
Centaurea pallescens Del.	Near East	Herb
Cichorium endivia L.	Europe	Herb
C. intybus L.	India	Herb
Chrysanthemum coronarium L.	Near East, Malaysia	Herb
C. indicum L.	India	Herb
C. segetum L.	Indochina	Herb
Calinsoga parviflora Cav.	Philippines	Herb
Conyza aegyptiaca Ait.	Congo	Herb
Cosmos caudatus H.B.K.	Pantropical	Herb
C. sulphureus Car.	Mexico	Herb
Crassocephalum biafrae S. Moore	West Africa	Herb
C. crepidioides S. Moore	West Africa	Herb
C. rubens S. Moore	West Africa	Herb
C. vitellinum S. Moore	West Africa	Herb
Crepis aspera L.	Near East	Herb
C. reuteriana Boiss. et Heldr.	Near East	Herb
Cymboseris palestinae Boiss.	Near East	Herb
Cynara cardunculus L.	South Europe and South America	Herb
C. scolymus L.	South Europe	Herb
Cynara sp.	Mediterranean region, and Canary Islands	
Eclipta alba Hassk.	Java	Herb
Emilia sagittata DC.	Tropics of New World	Herb
E. sonchifolia A. DC.	Pantropical	Herb
Enhydra fluctuans Lour.	Africa and Asia	Herb

Species	Source	Plant type
Erechtites hieracifolia Rafin. ex. DC.	East India	Herb
E. valerianaefolia A. DC.	Tropical America	Herb
Erigeron sumatrensis Retz	Southeast Asia Islands	Herb
Ethulia conyroides L.	East Africa	Herb
Galinsoga parviflora Cav.	Java	Herb
Glossocardia bosvallia D.C.	India	Herb
Gynura cernua Benth.	West Africa	Herb
G. procumbens Backer	Indonesia	Herb
G. sarmentosa DC.	Indonesia	Herb
Hedypnois polymorpha DC.	Africa	Herb
Hyoseris radiata L.	Liberia	Herb
Inula crithmoides L.	Near East	Herb
Koelpinia linearis Pallas	Africa	Herb
Lactuca alpina Benth et Hook.f.	Europe	Herb
L. capensis Thunb	Madagascar	Herb
L. indica L.	Indonesia, Philippines	Herb
L. intybacea Jacq.	Madagascar	Herb
L. plumieri	France	Herb
L. sativa L.	Pantropical	Herb
L. taraxacifolia Sch. et Thon.	Nigeria	Herb
L. tuberosa	Near East	Herb
Laggera alata Sch. Rip.	Congo, West Africa	Herb
Launaea glomerata Hook. f.	Sahara	Herb
L. nudicaulis Hook. f.	Near East	Herb
Microglossa afzelii O. Hoffm.	Sierra Leone	Herb
Mikania cordata B.L. Robinson	Africa	Herb
M. scandens Willd.	Congo	Herb
Myriactis wallichii L.	India	Herb
Nidorella macrocephala Steetz.	Africa	Herb
Ornopodon sp.	Africa	Herb
Pacourina edulis Aubl.	Guiana	Aquatic plant
Petasites japonicus F. Schmidt.	Japan	Herb
P. palmatus Ase Gray	California	Herb
Petasites sp.	Pacific Islands	Herb
Pluchea indica (L.) Less	Southeast Asia	Tree
Rhapontic[illegible]um acaule D.C.	Libya	Herb
Scolymus grandiflorus Desf.	North Africa	Herb

Species	Source	Plant type
Scolymus hispanicus L.	North Africa, Canarias	Herb
S. maculatus L.	North Africa	Herb
Scorzonera alexandrina Briss.	Libya	Herb
S. undulata Vahl	Algerie, Morocco	Herb
S. congolensis de Wild	Congo	Herb
S. gabonensis	Gabon	Herb
Senecio triafrae Olw. et Hiern.	Africa	Herb
Silybum marianum Gaertn.	North Africa	Herb
Sonchus arvensis L.	Old World	Shrub
S. asper Hill	Old World	Shrub
S. bipontini A[illegible]	Old World	Herb
S. exauriculatus O. Hoffm.	Old World	Herb
S. oleraceus L.	Old World	Herb
Spilanthes acmella Merr.	Tropical America, Africa	Herb
S. jabadiensis H. H. Moore	Tropical America, Africa	Herb
S. ocymifolia A. H. Moore	Tropical America, Africa	Herb
S. oleracea Jacq.	Tropics	Herb
S. paniculata Wall.	Tropics	Herb
Struchium sparganophora O. Ktz.	Africa	Herb
Synedrella nodiflora Gaertn.	Indonesia	Herb
Tagetes patula L.	Congo	Herb
Taraxacum officinale Weber	Worldwide	Herb
Tragopogon pratensis L.	Near East	Herb
Urospermum picroides F.W. Schmidt.	Near East	Herb
Vernonia amygdalina Dal.	Africa	Herb
V. appendiculata Less.	Worldwide	Herb
V. biafrae Oliv. et Hiern.	Worldwide	Herb
V. calvoana Hook. f.	Worldwide	Herb
V. chinensis Less.	Worldwide	Herb
V. cinerea Less.	West and South Africa	Herb
V. colorata Drake	Worldwide	Herb
V. gastigiata Oliv. et Hiern.	Worldwide	Herb
V. perrottetii Sch. Bip.	Worldwide	Herb
V. senegalensis L.	Worldwide	Herb
Wedelia biflora DC.	Southeast Asia, Polynesia	Herb
Zinnia elegans Jacq.	Mexico	Herb

CONNARACEAE

Species	Source	Plant type
Agelaea hirsuta de Wild.	Congo	
Castanola paradoxa (Gilg.)	South Nigeria	

CONVOLVULACEAE

Aniseia martinicensis Choisy	Malaysia	Vine
Argyreia populifolia Choisy	Ceylon, India	Vine
Calligonum polygonoides L.		Shrub
Calonyction aculeatum House	Pantropical	Vine
C. bona-nox Boj.	India	Vine
C. muricatum G. Don.	India	Vine
Dipteropeltis poranoides Hall. f.	Central Africa	Vine
Ipomoea batatas Poir	Tropical America	Vine
I. biloba Forsk.	Pantropical	Vine
I. cairica Sweet	Pantropical	Vine
I. cordofana Choisy	Pantropical	Vine
I. digitata L.	India	Vine
I. eriocarpa R. Br.	India	Vine
I. hochstetteri House	South Africa	Vine
I. illustris Prain	India	Vine
I. involucrata Beauv.	Pantropical	Vine
I. lugardi N.E. Br.	India	Vine
I. pes-caprae R. Br.	Pantropical	Vine
I. reptans Poir	Southeast Asia	Vine
I. sepiaria Koenig ex Rob.	India	Vine
I. triloba L.	New World Tropics	Vine
I. uniflora Roem. et Schult.	India	Vine
Jacquemontia tamnifolia Gris.	America, Africa	Vine
Merremia emarginata Hall. f.	India	Vine
M. rhyncorhiza Hall. f.	India	Vine
M. umbellata Hall.	Indonesia	Vine
Neuropeltes acuminata Benth.	Equatorial Africa	Vine
Operculina turpethum S. Mans.	Philippines	Vine
Quamoclit pinnata Boyer	Pantropical	Vine
Rivea ornata Choisy	India, Southeast Asia	Vine

CRUCIFERAE

Species	Source	Plant type
Barbarea verna Asch.	North temp.	Shrub
Brassica alba Baiss	Europe	Herb.
B. campestris L. a.o. var. sarson Prain	India	Herb
B. chinensis L.	China	Herb
B. hirta Moench	Pantropical	Herb
B. integrifolia Schultz	Africa (Gabon)	Herb
B. juncea Czern. & Coss.	Pantropical	Herb
B. napus	Pantropical	Herb
B. nigra Kich	India	Herb
B. oleracea L. (all forms)	Worldwide	Herb
B. pekinensis (Lour.) Rupr.	Tropical Africa, Madagascar	Herb
B. rapa L.	Africa	Herb
B. rugosa Prain	Africa, India	Herb
B. schimperi Boiss	Africa, India	Herb
B. tournefortii Gonan	Africa, India	Herb
B. sinensis Juslen.	Tropical Africa	Herb
Cakile fusiformis Greene	South Florida	Herb
Capsella bursa-pastoris Medik	Near East, North Africa	Herb
Cardamine hirsuta R.	India	Herb
Cochlearia armoracea L.	Southeast Asia	Herb
Coronopus squamatus Asch.	Near East	Herb
Crambe abyssinica Hochst. ex R.E. Fries	Ethiopia	Herb
C. cordifolia Steven	Asia Minor, India, Ethiopia	Herb
C. maritima L.	Atlantic & Mediterranean European Coast	Herb
Diplotaxis duveyrierana Coss.	Africa	Herb
D. pendula DC.	Africa	Herb
Eruca sativa Mill	Near East	Herb
Lepidium africanum DC.	Africa	Herb
L. chilense Kunze	South America	Herb
L. draba L.	India	Herb
L. myriocarpum Lond.	South Africa	Herb
L. sativum L.	Europe	Herb
L. virginicum L.	North America	Herb
Nasturtium barbariaefolium Baker	Africa	Herb
N. fluviatilis R.A. Dyer	Africa	Herb
N. heterophyllum Bl.	Southeast Asia	Herb
N. microphyllum	Worldwide	Herb
N. officinale L.	Worldwide	Herb
Raphanus sativus L. var. hortensis Backer	Europe & Asia	Herb

Species	Source	Plant type
Raphia faranifera (Gaertn.) Hylander	Madagascar, Trop. Africa	Palm
Rapistrum rugosum All.	Near East	Herb
Rorippa humifusa (Guill. et Perr.) Hiern.	Congo	
Senebiera coronopus Poir	Pantropical	Herb
S. lepidioides Coss. et Dur.	North Africa	Herb
S. pinnatifida DC.	California	Herb
Sinapsis alba L.	India	Herb

CRYPTERONIACEAE

Crypteronia paniculata Bl.	Southeast Asia	Tree

CUCURBITACEAE

Benincasa hispida Cogn.	Tropical Asia, India	Vine
Bryonopsis laciniosa Naud.	India	Herb
Cephalandra quinqueloba Schrad	Africa	Herb
Citrullus vulgaris Schrad. ex Eckl. et Zeyh	Tropical & South Africa	Vine
Coccinia cordifolia Cogn.	Southeast Asia, India	Vine
C. rehmannii Don	Tropical Africa, Asia	Vine
C. sessilifolia Cogn.	South Africa	Vine
Cogniauxia podolaena Baill.	Africa	Herb
Corallocarpus sphaerocarpus Ait.	Africa	Herb
Cucumello robicchii Chior.	Africa	Herb
Cucumis africanus Lindl.	Africa	Vine
C. egrestis Creb.	Africa	Vine
C. dipsaceus Spach.	Africa	Vine
C. ficifolius A. Rich	Africa	Vine
C. hirsutus Sond.	Africa	Vine
C. prophetarum L.	Africa	Vine
C. sativus L.	South Asia	Vine
Cucurbita maxima Duch.	Pantropical	Vine
C. moschata Duch. ex Poir	Pantropical	Vine
C. pepo L.	Pantropical	Herb
Cyclanthera pedata Schrad.	Mexico	Vine

Species	Source	Plant type
Lagenaria leucantha Rusby	India	Vine
L. sphaerica (E. Mey. ex Sond.) Naud.	Malawi	Vine
Luffa acutangula Roxb.	Asia	Vine
Melothria heterophylla Cogn.	India	Vine
Momordica charantia L.	Pantropical	Vine
M. cochinchinensis (Lour.) Spreng.	Southeast Asia	Vine
Polakowskia tacaco Pitt.	South America	Herb
Sechium edule Sw.	North & Tropical Africa	Vine
Sphaerosicyos sphericus Hook. f.	Africa	Herb
Telfairea occidentalis Hook. f.	Africa	Vine
T. pedata Hook.	Africa	Vine
Trichosanthes anguina L.	Indonesia	Vine
T. celebica Congn.	Indonesia	Vine
T. cucumerina L.	Japan	Vine
T. dioica Roxb.	Tropical Asia, North Australia, Polynesia	Vine
T. diseca	India	Vine
T. palmata Roxb.	India	Vine
T. ovigera Bl.	Tropical Asia, North Australia, Polynesia	Vine

CYCADACEAE

Cycas circinalis L.	Southeast Asia	Tree
C. rumphii Miq.	Southeast Asia	Tree

CYPERACEAE

Scleria tessellata Willd.	Southeast Asia	Herb

DILLENIACEAE

Tetracera alnifolia Willd.	Equatorial Africa	Tree
T. potatoria Afzel. ex G. Don	Equatorial Africa	Tree

EBENACEAE

Species	Source	Plant type
Diospyros kaki L.	Subtropics	Tree
D. virginiana var. mosieri	South Florida	Tree

ERICACEAE

Vaccinium varingiaefolium Miq.	Indonesia	Shrub

EUPHORBIACEAE

Acalypha boehmeroides Miq.	Tropical and Subtropics	Shrub
A. caturus Bl.	Tropical and Subtropics	Shrub
A. indica L.	India	Shrub
A. paniculata	Tropical and Subtropics	Shrub
A. wilkesiana Muell.	South Sea Islands	Shrub
Anthriscus arefolium Hoffm.		Herb
Antidesma bunius Spreng.	Indonesia	Tree
A. diandra Roxb.	India	Tree
A. ghaesembila Gaertn.	India	Tree
Aporosa maingayi Hook. f.	Malaysia, Southeast Asia	Tree
Baccaurea sapida Muell. Arg.	Southeast Asia	Tree
Breynia discigera Muell. Arg.	Malaysia	Tree
B. reclinata Hook. f.	Malaysia	Shrub
Bridelia scleroneura Muell. Arg.	Africa	Tree
Claoxylon longifolium Juss.	Southeast Asia	Shrub
C. oleraceum O. Prain	Congo	Tree
C. polot Merr.	Southeast Asia	Tree
Cleistanthus heterophyllus Hook. f.	Southeast Asia, Malaysia	Shrub
Cnidoscolus chayamansa McVaugh	Mexico	Shrub
Codiaeum variegatum Bl.	Pantropical	Shrub
Croton mubange Muell. Arg.	Congo	Shrub

Species	Source	Plant type
Crotonogyne poggei Pax	Tropical Africa	
Erythrococca columnaris Prain	Equatorial Africa	
E. oleracea (Prain) Prain	Equatorial Africa	
Euphorbia antiquorum L.	Java	Shrub
E. balsamifera Ait.	Senegal	Shrub
E. edulis Lour.	Indochina	Herb
E. heterophylla L.	New World Tropics	Herb
E. hirta L.	India	Herb
E. nerifolia L.	Malaysia	Herb
E. pulcherrima Willd.	Pantropical	Shrub
E. trigyna Haw.	Java	Shrub
Glochidion blancoi Lowe	Far East, Philippines	Tree
G. borneense Boerl	Southeast Asia	Tree
G. rubrum Bl.	Southeast Asia	Tree
Hymenocardia acida Tul.	Congo	Shrub
H. ulmoides Oliv.	Congo	Shrub
Jatropha curcas L.	Pantropical	Shrub
J. multifida L.	Mexico	Shrub
J. urens L.	Philippines	Shrub
Maesobotrya bertramiana Buttn.	Congo	Shrub
M. floribunda Benth.	Africa	Shrub
M. hirtella Pax	Africa	Shrub
Manihot esculenta Crantz	Pantropical	Shrub
Maprounea africana Muell. Arg.	Congo	Shrub
M. membranacea Pax et Hoffm.	Congo	Shrub
Micrococca mercurialis Benth.	Congo	Shrub
Microdesmis pentandra Hook. f.	Congo	Tree
M. puberula Hook. f.	Congo	Tree
M. zenkeri Pax	Congo	Tree
Phyllanthus acidus Skeels	Tropical Asia	Tree
P. emblica L.	Tropical Asia	Tree
P. muellerianus Excell	West Africa	Tree
Pterococcus corniculatus Pax et Hoffm.	Malaysia	Vine
Ricinus communis L.	Pantropical	Shrub
Sauropus androgynus Merr.	Southeast Asia	Shrub
Tetracarpidium commophorum Hutch	Congo & Sierra Leone	Tree

FLACOURTIACEAE

Species	Source	Plant type
Flacourtia jangomas Roeusch.	Indonesia	Tree
F. rukam Zoll. et Mor.	Indonesia, India	Tree

GENTIANACEAE

Limnanthemum cristatum Griseb.	Malaysia	Aquatic plant
L. indicum Thw.	India	Herb

GERANIACEAE

Erodium moschatum l'Her	Near East	Herb
Impatiens balsamina L.	Indonesia	Herb
I. dichiva Hook. f.	Congo	Herb
I. flaccida Arn.	Ceylon	Herb
Tropaeolum majus L.	South America	Herb

GESNERIACEAE

Cyrtandra decurrens de Vr.	Indonesia	Herb
Klugia notoniana A. D.C.	Southeast Asia	Herb

GNETACEAE

Gnetum gnemom L.	Southeast Asia	Tree
G. africanum Welv.	West Africa	Tree
G. buchholzianum Engl.	West Africa	Tree
G. indicum Merr.	Africa	Tree
G. tisserantii	Africa	Tree

GRAMINEAE

Acroceros amplectans Stapf.	Gambia	Herb
Aristida gracilior Pilg.	Africa	Herb
A. plumosa L.	Africa	Herb
A. stipoides Lam.	Africa	Herb

Species	Source	Plant type
Bambusa arundinacea Willd.	South Asia	Bamboo
B. atra Stapf.	South Asia	Bamboo
B. bambos Backer	South Asia	Bamboo
B. multiplex Baensch	South Asia	Bamboo
B. spinosa Bl.	South Asia	Bamboo
B. vulgaris Schrad	Pantropical	Bamboo
Cymbopogon citratus Stapf.	Tropics of the Old World	Herb
Dendrocalamus asper Backer	Southeast Asia	Bamboo
D. hamiltonii Ness et Ern.	Southeast Asia	Bamboo
Digitaria gayana A. Chev.	Africa	Herb
Echinochloa colonum (L.) Link	Java	Herb
E. crus-galli Beauv.	Indonesia	Herb
Eleusine coracana Gaerth.	Africa	Herb
E. indica Gaertn.	Tropics of the Old World	Herb
Gigantochloa verticillata	Southeast Asia	Bamboo
Hyparrhenia spp.	Africa	Herb
Isachne albens Trin.	Southeast Asia	Herb
I. globosa O. Ktze.	Southeast Asia	Herb
Oxytinanthera abyssinica Munro	Uganda	
Panicum barbatum Lam.	Southeast Asia	Herb
P. chamaeraphioides Hack	Southeast Asia	Herb
P. colonum L.	Southeast Asia	Herb
P. crus-galli L.	Southeast Asia	Herb
P. palmifolium Koenig	Southeast Asia	Herb
Rhynchelythrum repens C.E. Hubb	Africa	Herb
Saccharum officinarum L.	Pantropical	Herb
Schizostachyum brachcladum Kurz.	Southeast Asia	Herb
Setaria palmifolia Stapf.	New Guinea	Herb
Themeda gigantea Hack.	Southeast Asia	Herb
Zea mays L. var. rugosa	Madagascar	Herb
Zizania latifolia Turcz.	Singapore, China, Hong Kong	Herb

GUTTIFERAE

Garcinia atrovirides Griff.	Malaysia	Tree
G. cowa Roxb.	India, Thailand	Tree
G. dioica Bl.	Southeast Asia	Tree

Species	Source	Plant type
Garcinia microstigma Kurz	Burma	Tree
G. sizygifolia Pierre	Southeast Asia	Tree
HAMAMELIDACEAE		
Altingia excelsa Nor.	Southeast Asia	Tree
HYDROCHARITACEAE		
Hydrella sp.	India	Aquatic plant
Hydrocharis dubia Backer	Southeast Asia	Herb
Ottelia alismoides Pers.	Philippines	Aquatic plant
Vallisneria gigantea Gaertn.	Philippines	Herb
HYDROPHYLLACEAE		
Hydrolea zeylanica Vahl.	Southeast Asia	Aquatic plant
HYPERICACEAE		
Cratoxylon polyanthum Korth.	Thailand	Tree
Psorospermum tenuifolium DC.	Congo	Shrub
LABIATAE		
Aeolanthus frutescens	Africa	Herb
A. helitropioides Chev.	Africa	Herb
A. pubescens Benth.	Africa	Herb
Coleus aromaticus Benth.	Africa	Herb
C. rotundifolius Chev. et Perr.	Africa	Herb
C. tuberosus Benth.	Africa	Herb
Hausmaniastrum lilacinum J.K. Morton	Africa	Herb

Species	Source	Plant type
Hoglundia oppositifolia Vahl.	Congo	Herb
Hyptis brevipes Poir	Thailand, India and Indochina	Herb
H. pectinata Port.	Africa	Herb
H. spicigera Lam.	Africa	Herb
H. suavealens Poir	Indochina, Thailand	Herb
Leucas cephalates Spreng.	India	Herb
L. clarkii Hook. f.	India	Herb
L. lanata Benth.	India	Herb
L. lavandula Smith	Indonesia	Herb
L. martinicensis R. Br.	India	Herb
L. mollissima Wall.	India	Herb
L. zeylanica R. Br.	Ceylon	Herb
Mentha arvensis L.	Pantropical	Herb
M. piperita L.	Pantropical	Herb
M. spicata L.	Pantropical	Herb
Ocimum americanum L.	New World Tropics	Herb
O. arborescens Bl.	Congo	Herb
O. basilicum L.	Tropical Asia and Africa, Pacific Islands	Herb
O. canum Sims.	Indonesia	Herb
O. sanctum L.	Southeast Asia	Herb
O. viridi Willd.	West Africa	Herb
Origanum majorana L.	Mediterranean region	Herb
O. onites L.	Mediterranean region	Herb
O. vulgare L.	Mediterranean region	Herb
Perilla frutescens Britt		
Platystoma africanum P. Beauv.	Congo	Herb
Plectranthus kamerunensis Gurke	Central Africa	Herb
Rosmarinus officinalis L.		Herb
Salvia hispanica	Spain	Herb
S. officinalis L.	Worldwide	Herb
S. verbenaca L.	Africa	Herb
Solenostemon monostachus Briq.	Africa	Herb
S. ocymoides Chum.	Guinea Coast	Herb
Thymus vulgaris L.	Tropics	Herb
LAURACEAE		
Litsea firma Hook. f.	Thailand	Tree
L. glaucescens HBK.	Guatemala	Tree
L. guatemalensis Mez.	Guatemala	Tree

Species	Source	Plant type
Persea borbonia Spreng	South Florida	Shrub
LECYTHIDACEAE		
Barringtonia acutangula Gaertn.	Southeast Asia	Tree
B. asiatica Kurz.	Thailand	Tree
B. fusiformis King.	Malaysia	Tree
B. insignis Miq.	Southeast Asia	Tree
B. racemosa Roxb.	Malaysia	Tree
B. spicata Bl.	Southeast Asia	Tree
Planchonia grandis Ridl.	Malaysia	Tree
P. valida Bl.	Southeast Asia	Tree
LEEACEAE		
Leea manillensis Walp.	Philippine Isls.	Tree
LEGUMINOSAE		
Abrus precatorius L.	Pantropical	Tree
Acacia albida Del.	South Rhodesia	Tree
A. arabica Willd.	Africa	Shrub
A. concinna DC.	India, Philippines	Shrub
A. farnesiana Willd.	Southeast Asia	Tree
A. drepanolobium Harms, ex Sjostedt	East Africa	Tree
A. insuavis Laco.	Thailand	Vine
A. macrothyrsa Harms.	Malawi	Shrub
A. nilotica Del.	West Africa	Shrub
A. socotrana Balf. f.	Somali	Shrub
A. zygia L.	Africa	Shrub
Afzelia africana Smith	Africa	Tree
A. bijugar A. Gray.	Thailand	Tree
A. quanzensis Welw.	Africa	Tree
A. xylocarpa Craib	Thailand	Tree
Albizzia adianthifolia (Schum.) W.F. Wight	Congo	Tree
A. chevalieri Harnes.	Nigeria	Tree
A. gemmifera C.A. Smith	Africa	Tree
A. procera Benth.	Southeast Asia	Tree
A. zygia J.F. Mackr.	Africa	Tree
Arachis hypogaea L.	Brazil	Herb

Species	Source	Plant type
Astragalus abyssinicus A. Rich	Africa	Herb
Bauhinia esculenta Burch.	South and Tropical Africa	Tree
B. malabarica Roxb.	Malaysia	Tree
B. nonandra	Guiana	Tree
B. purpurea L.	India, China	Tree
B. reticulata DC.	Africa	Tree
B. tomentosa L.	Tropical Asia	Tree
B. variegata L.	Tropical Asia	Tree
Cajanus cajan Millsp.	Old World	Herb
Calopogonium muconoides Desv.	New World Tropics	Vine
Canavalia ensiformis DC.	West Indies	Herb
Cassia alata L.	Pantropical	Tree
C. angustifolia Vahl	India	Tree
C. auriculata L.	India	Shrub
C. fistula L.	India	Tree
C. garrettiana Craib.		Herb
C. hirsuta L.	New World Tropics	Herb
C. laevigata Willd.	Tropics	Herb
C. mimosoides L.	Southeast Asia	Tree
C. obtusifolia L.	South America	Herb
C. occidentalis L.	Pantropical	Shrub
C. siamea Lam.	Southeast Asia	Tree
C. singueana Del.	Southeast Asia	Tree
C. surattensis Burm. F.	India	Tree
C. tomentosa L.	Mexico	Tree
C. tora L.	Tropical Asia	Shrub
Ceratonia siliqua L.	North Africa	Tree
Cicer arietinum L.	Mediterranean region	Herb
Clitoria ternatea L.	Asia, Molucca Islands	Vine
Crotalaria falcata Vahl. ex D.C.	Nigeria	Herb
C. glauca Willd.	Equatorial Africa	Herb
C. juncea L.	India	Herb
C. longirostrata Hook. et Arn.	West Mexico, Guatemala	Herb
C. microcarpa Hochst. ex Benth.	Tanzania	Herb
C. ochroleuca G. Don.	Central Africa	Herb
C. retusa L.	Central Africa	Herb
Cyamopsis psoraloides C.C.	India	Herb
C. senegalensis Cyr. et Poir	Tropic and Subtropical Africa, Arabia, India	Herb

Species	Source	Plant type
Cynometra reniflora L.	Thailand	Tree
Daniella olivieri Hutch. et Dalz.	Africa	Tree
Delonix alata Gamble	India	Tree
Derris elliptica Benth.	Thailand	Vine
D. heptaphylla Merr.	Thailand	Vine
D. oliginosa Benth.	Thailand	Vine
Desmodium cinereum DC.	Indonesia	Shrub
D. umbellatum	South America	
Dewevrea bilabiata M. Micheli	Congo	Tree
Dolichos bracteatus Baker	India	Vine
D. lablab L.	Tropics	Vine
Dysoxylum euphlebium Merr.	Indonesia	Vine
Entada phaselioides Merr.	Indonesia	Vine
E. scandens Benth	Congo	Vine
Eriosema glomeratum (Guill. et Perr.) Hook. f.	Congo	Herb
Erythrina berteroana Urb.	Tropical and Subtropical	Tree
E. fusca Lour.	China	Tree
E. herbacea L.	Florida	Shrub
E. subumbrans Merr.	Indonesia	Tree
E. variegata L.	India	Tree
Flemingia macrophylla Kuntze	India	Shrub
Gliricidia maculata H.B.K.	Pantropical	Tree
G. sepium (Jacq.) Steud	Pantropical	Tree
Glycine japonicum L.	Japan	Herb
G. laurentii de Wild.	Pantropical	Herb
G. max Merr.	Pantropical	Herb
Indigofera arrecta Hochst.	Pantropical	Tree
Leucaena esculenta Benth.	Mexico	Tree
L. leucocephala de Wit	Pantropical	Tree
Lolium rigidum Gaud.	Algeria	Herb
Lotus edulis L.	India	Tree
Medicago denticulata Willd.	India	Herb
M. sativa L.	India	Herb
Millettia sericea W. et A.	Southeast Asia	Vine
Mucuna aterrima Holland	Eastern Asia	Vine

Species	Source	Plant type
Mucuna utilis Wall ex Wight	Tropical & Subtropics	Herb
Neptunia oleracea Lour.	Thailand	Aquatic plant
N. prostrata Baill.	Southeast Asia	Aquatic plant
Parkia speciosa Hort. ex Hassk.	Southeast Asia	Tree
Parochetus communis Buch. Ham. ex D. Don	East Africa	Vine
Phaseolus aureus Roxb.	Worldwide	Herb
P. calcaratus Roxb.	Worldwide	Herb
P. coccineus L.	Worldwide	Vine
P. limensis Macf.	Worldwide	Herb
P. lunatus L.	Worldwide	Herb
P. vulgaris L.	Worldwide	Herb
Piliostigma malabaricum Benth.	Thailand	Shrub
Pisum arvense L.	Worldwide	Herb
P. sativum L.	Worldwide	Herb
Pithecelobium kunstleri Prain	Sumatra	Tree
Psophocarpus palustris Desv.	Congo	Herb
P. tetragonolobus (L.) DC.	Southeast Asia	Herb
Pterocarpus angolensis DC.	Angola	Tree
P. erinaceus Poir	Africa	Tree
P. indicus L.	India	Tree
P. lucens Lepr.	Africa	Tree
P. santaloides l'Her	Africa	Tree
Pueraria thunbergiana Benth.	China, Japan	Vine
Saraca indica L.	Thailand	Tree
Sesbania aegyptiaca Pers.	Tropics of the Old World	Shrub
S. grandiflora Pers.	Pantropical	Tree
S. roxburghii Merr.	India	Herb
S. tetraptera Hoechst.	Sudan	Herb
Sesuvium portulacastrum (L.) L.	Tropical Africa	Herb
Smithia elliotti Bak. f.	Africa	Shrub
S. sensitiva Ait.	Malaysia, Old World Tropics	Herb
Sphenostylis briarti Bak. f.	Africa	Vine
S. erecta Hutch	Africa	Vine
S. schweinfurthii Harms.	Africa	Vine
S. stenocarpa Harms.	Africa	Vine
Tamarindus indica L.	Pantropical	Tree
Tephrosia elegans Schum.	Africa	Herb

Species	Source	Plant type
Tephrosia linearis Pers.	Pantropical	Herb
T. purpurea Pers.	Pantropical	Herb
T. vogelii Hook.	Africa	Herb
Teramnus labialis Spreng.	Southeast Asia	Vine
Tetrapleura tetraptera Taub.	Africa	Tree
Trigonella foenum-graecum L.	India	Herb
T. corniculata L.	Africa	Herb
T. occulta Del.	Africa	Herb
T. polycerata L.	Africa	Herb
Tylosma fassogiensis Torre et Hill.	Africa	Tree
Uraria crinita Desv.	Malaysia and Sumatra	Herb
Vicia abyssinica	Malawi	Herb
V. faba L.	Worldwide	Herb
Vigna marina Merr.	Tropical seashores	Herb
V. marginata Benth.	Pantropical	Herb
V. mungo Hepper	Madagascar	Herb
V. phaseoloides Baker	Africa & Asia	Herb
V. reticulata Hook. f.	Tropics	Herb
V. sinensis Savi ex Hook.	Asia	Herb
V. triloba Walp.	Tropics	Herb
Virecta procumbens Sm.	Congo	Herb
Voandzeia subterranea Thouars.	Africa	Herb
Whitfordiodendron atropurpureum Donn.	Thailand and Burma	Tree

LEMNACEAE

Lemna minor L.	Pantropical	Aquatic plant

LILIACEAE

Allium angolense Baker		Herb
A. ascalonicum L.	East Asia	Herb
A. cepa L.	Worldwide	Herb
A. fistulosum L.	Asia	Herb
A. kurrat Schweinf. ex. K. Krause	Near East	Herb

Species	Source	Plant type
Allium odorum L.	Siberia and Japan	Herb
A. porrum L.	Europe	Herb
A. sativum L.	Europe	Herb
A. schoenoprasum L.	Europe	Herb
Aloe baumii Engl. et Gilg.	Angola	Herb
A. saponaria Haw.	Africa	Herb
A. vaombe Dec. et Forsk.	Madagascar	Herb
Anthericum subpetiolatum Baker	Africa	Herb
Asparagus acutifolius L.	Libya	Herb
A. africanus Lam.	South Africa	Herb
A. albus L.	Algeria	Herb
A. aphyllus L.	Libya	Herb
A. capensis L.	South Africa	Herb
A. declinatus L.	South Africa	Herb
A. laricinus Burch.	South Africa	Herb
A. officinalis L.	N E & South Africa	Herb
A. paul-guilielmi Solms-Laub.	Tropical Africa	Herb
A. racemosus Willd.	Sudan	Herb
A. stipularis Forsk.	Libya	Herb
A. suaveolens Burch.	South Africa	Herb
Asphodelus fistulosus L.	North Africa	Herb
A. tenuifolius Cor.	North Africa	Herb
Cordyline fruticosa A. Chev.	Southeast Asia	Shrub
Dracaena angustifolia Lam.	Africa	Shrub
D. mannii Baker	Africa	Shrub
D. reflexa L.	Africa	Shrub
D. thalioides Ch. Morren	Africa	Shrub
Gloriosa virenseens Lindl.	Congo	Vine
Muscari comosum Mill.	Liberia	Herb
Pleomele angustifolia N.E. Brown	Philippines	Shrub
P. elliptica N.E. Brown	Philippines	Shrub
Smilax bona-nox	Florida	Shrub
S. leucophylla Blume	Malaysia	Vine
Tulbaghia camerooni Baker	Tropics and South Africa	Herb
Yucca aloifolia L.	Central America	Herb
Y. elefantopes Hort.	Central America	Herb

LOGANIACEAE

Species	Source	Plant type
Strychnos spinosa Lam.	Africa	Shrub
S. suberosa de Wild	Congo	Shrub

LORANTHACEAE

Globimetula braunii (Engl.) van Liegh.	Tropical Africa	
Loranthus sp.	Africa	Herb

LYTHRACEAE

Lagerstroemia macrocarpa	Thailand	Tree
Pemphis acidula Forst.	Indonesia, Polynesia	Tree

MALVACEAE

Abutilon cabrae de Wild. et Th. Dur.	Congo	Shrub
A. indicum (L.) G. Don	Tropics	Shrub
Gossypium arboreum L.	Thailand	Shrub
G. brasiliense Macf.	Thailand	Shrub
G. herbaceum L.	Thailand	Shrub
Hibiscus abelmoschus L.	Southeast Asia, West Africa	Shrub
H. acetosella Fic.	Pantropical	Shrub
H. articulatus A. Rich	Cameroun	Shrub
H. asper Hook. f.	Volta	Shrub
H. cannabinus L.	Pantropical	Shrub
H. eetveldianus de Wild. et Th. Dur.	Africa	Shrub
H. esculentus L.	Pantropical	Herb
H. ficulneus L.	Africa	Shrub
H. gilletii de Wild.	Congo	Shrub
H. manihot L.	Indonesia, Pacific	Shrub
H. physaloides Guill. et Perr.	Congo	Shrub
H. radiatus Cav.	India, Java	Shrub
H. rosa-sinensis L.	Pantropical	Shrub
H. rostellatus Guill. et Perr.	Tropical Africa	Shrub

Species	Source	Plant type
Hibiscus sabdariffa L.	Pantropical	Herb
H. surattensis L.	Philippines	Shrub
H. tiliaceus L.	Pantropical	Shrub
Hilleria latifolia (Lam.) Walter	Congo	Herb
Malva parviflora L.	India, Near East	Herb
M. rotundifolia L.	India, Near East	Herb
M. niaceensis All.	India, Near East	Herb
Sida alba L.	Tchad, Malawi	Herb
S. humilis Willd. var. moriflora	Central & South America	Herb
S. rhombifolia L.	Central & South America	Herb
Thespesia populnea Soland.	Southeast Asia, South Florida, Old World Tropics	Shrub
Triplochiton scleroxylon K. Schum.	Africa	Tree
Urena lobata L.	Madagascar	Shrub

MARANTACEAE

Calathea macrosepala K. Schum.	Central America	Herb
Phrynium confertum K. Schum	Congo	Herb
Sarcophrynium arnoldianum de Wild.	Congo	Herb

MARSILEACEAE

Marsilea crenata Presl.	Madagascar, Indonesia	Herb

MELASTOMATACEAE

Amphiblemna willdemanium Cogn.	Congo	Shrub
Astromia papetaria Blume	Polynesia, Indonesia	Tree
Dicellandra barteri Hook.	Congo	
Dichaetanthera corymbosa (Cogn.) Jac. Fel.	Congo	

Species	Source	Plant type
Dinophora spenneroides Benth.	Gabon	
Dissotis decumbens Triana	Congo	Herb
D. hassii Cogn.	Congo	Herb
D. multiflora Triana	Southeast Asia	Herb
D. prostrata Triana	Southeast Asia, Africa	Herb
D. sylvestris J. Felix	Southeast Asia, Africa	Herb
Marumia muscosa Bl.	Southeast Asia	Vine
Medinilla hasseltii Blume	Malaysia, Southeast Asia	Shrub
M. rubicunda Bl.	India	Shrub
Melastoma malabathricum L.	Pacific Islands, Southeast Asia	Shrub
Ochthocharis borneensis Blume	Malaysia	Shrub
Phaeoneuron dicellandroides Gilg.	Congo	
Takersia laurenti Cogn.	Congo	
Tristema grandiflorum de Wild.	Congo	

MELIACEAE

Azadirachte indica Juss.	India	Tree
Cedrela sinensis Juss.	Southeast Asia	Tree
Melia excelsa Jack.	Malaysia	Tree
M. indica Brand.	Malaysia	Tree
Turraea vogelii Hook. f.	Congo	Tree

MENISPERMACEAE

Limaciopsis loangensis Engl.	Africa	Vine

MORACEAE

Allaenthus luzonicus F. Will.	Philippines	Tree
A. glabra Warb.	Southeast Asia	Tree
Artocarpus champeden Spreng.	Southeast Asia	Tree
A. integra Merr.	Southeast Asia	Tree

Species	Source	Plant ty
Brosimum alicastrum SW.	Tropical America	Tree
Broussonetia papyrifera Vent.	Indonesia	Tree
Cecropia peltata L.	New World Tropics	Tree
Chlorophora excelsa Benth.	Africa	Tree
Craterogyne kameruniana (Engl.) Lanjouw		
Cudrania javensis Trec.	Indonesia	Shrul
Dammaropsis kingiana Warb.	Polynesia	Tree
Ficus alba Reinw.	Malaysia	Shrub
F. annulata Bl.	Malaysia	Tree
F. asperifolia Miq.	Cameroun	Tree
F. capensis Thunb.	Madagascar	Tree
F. dammaropsis Diels.	Indonesia	Tree
F. elastica Thunb.	India, Malaysia	Tree
F. fistulosa Reinw.	Southern Asia	Tree
F. glabella Bl.	Malaysia	Tree
F. glomerata Roxb.	India	Tree
F. glumosa Del.	Africa	Tree
F. gnaphalocarpa Steud.	Africa	Tree
F. infectoria Roxb.	India	Tree
F. ingens Miq.	Africa	Tree
F. lepicarpa Bl.	Malaysia	Tree
F. mucosa Welw.	Africa	Tree
F. polita Vahl	West Africa	Tree
F. pseudopalma Blanco	Philippines	Shrub
F. quercifolia Roxb.	Burma	Shrub
F. rumphii Bl.	Southeast Asia	Tree
F. variegata Bl.	India	Tree
Morus alba L.	Africa	Tree
Myrianthus achoreus P. Beauv.	West Africa	Tree
M. libericus Rendle	West Africa	Shrub

MORINGACEAE

Moringa bracteata Roxb.	India	Tree
M. oleifera Lam.	Pantropical	Tree
M. periguina (Forsk.) Fiori	Uganda	Tree

MUSACEAE

Ensete vetricosum (Welw.) E. E. Cheesman	Ethiopia	Large herb
Ravenala madagascariensis Sonn.	Madagascar	Tree

MYRSINACEAE

Aegiceras corniculatum Blanco	Indonesia	Shrub
Ardisia boisieri A. DC.	Indonesia	Shrub
A. crispa A. DC.	Southeast Asia	Shrub
A. humilis Vahl	Southeast Asia	Shrub
A. laevigata	Indonesia	Shrub
A. littoralis Andr.	Malaysia	Shrub
A. solanacea Roxb.	India	Shrub
Embelia philippinensis A. DC.	Philippines	Vine
E. ribes Burm. f.	Southeast Asia	Vine
E. schimperi Vatke	East Africa	Vine
Maesa blumei Alph. DC.	Southeast Asia	Shrub
M. chista Al. Don	India	Tree
M. indica Wall.	India	Tree

MYRTACEAE

Decapermum fruticosum Forst.	Southeast Asia	Shrub
Eugenia duthieana King	Thailand	Tree
E. grata Wight	Thailand	Tree
E. lineata Duthie	Indonesia	Tree
E. longiflora Fisch.	Tropics and Subtropics	Tree
E. malaccensis L.	Southeast Asia	Tree
E. polyantha Wight	Tropics and Subtropics	Tree
E. polycephala Miq.	Tropics and Subtropics	Tree
Melaleuca leucadendron L.	Australia	Tree
Pimenta acris Kostel	Africa	Tree
P. dioica Merr.	Tropics	Tree

NYCTAGINACEAE

Species	Source	Plant type
Boerhavia diffusa L.	Pantropical	Herb
B. plumbaginea	Africa	Herb
B. repens L.	Tropics and Subtropics	Herb
Pisonia alba Span.	Pantropical	Tree
P. sylvestris Teysm et Binnend	India, Java	Tree

NYMPHAEACEAE

Castalia pubescens (Willd) Blume	North America	Aquatic plant
Nelumbium nelumbo Druce	Southeast Asia	Aquatic plant

OCHNACEAE

Ourateae arnoldiana de Wild. et Th. Dur.	Congo	Shrub
O. leptoneura Gilq.	Africa	Shrub
Sauvagesia erecta L.	Congo	Herb

OLACACEAE

Meliantha suavis Pierre	Thailand	Shrub
Olax scandens Roxb.	Southeast Asia	Shrub
Ptychopetalum alliaceum de Wild.	Congo	Shrub
Sclorodocarpus borneensis Becc.	Malaysia	Tree
Strombosia javanica Blume	Malaysia	Tree
Ximenia americana L.	Indonesia	Shrub

ONAGRACEAE

Jussieua abyssinica Dandy et Bren.	Africa	Herb
J. repens L.	Pantropical	Aquatic plant
Ludwigia repens L.	Africa, Indochina	Herb

OPILCACEAE

Species	Source	Plant type
Champereia griffithii Hook. f.	Southeast Asia	Shrub

ORCHIDACEAE

Anaetochilus sp.	Malaysia	Herb
Habenaria sp.	Indonesia	Herb
Renanthera moluccana Bl.	Indonesia	Herb

OROBANCHACEAE

Cistanche philipea P. Cont.	Africa	Herb

OXALIDACEAE

Oxalis acetosella L.	South Africa	Herb
O. corniculata L.	East Africa, Congo, Madagascar	Herb
O. gigantea	Andes	Herb
O. obliquifolia Steud. ex A. Rich.	East Africa	Herb
O. repens Thumb.	Philippines	Herb
O. tuberosa Moline	Andes	Herb

PALMAE

Acanthophoenix crinita Wendl.	Madagascar	Palm
A. rubra Wendl.	Mascarene Islands, Mauritius and Bourbon	Palm
Acrocomia sclerocarpa Mart.	Brazil, Guyana, Trinidad	Palm
Ancistrophyllum secundiflorum (P. Beauv.) Wendl.	Africa	Palm

Species	Source	Plant type
Areca borneensis Becc.	Indonesia	Palm
A. catechu Merr.	Asia, Malaysia	Palm
Arenga ambong	Asia, Australia	Palm
A. engleri Becc.	Asia & Australia	Palm
A. pinnata Merr.	Asia & Australia	Palm
A. saccharifera Labill.	Malaysia	Palm
Borassus aethiopium Mart.	Africa	Palm
B. flabellifer L.	India	Palm
B. sundaica Becc.	India	Palm
B. tunicata Lour.	China, India	Palm
Caryota cumingii Lodd.	Malaysia, New Guinea, Australia	Palm
C. mitis Lour.	Southeast Asia, Indochina	Palm
Chamaedorea sp.	Warm America	Palm
Chamaerops humilis L.	North Africa	Palm
Cocos nucifera L.	Tropical Asia, Polynesia	Palm
C. oleracea Mart.	Brazil	Palm
C. yatay Mart.	Argentine	Palm
Copernica cerifera Wendl.	Madagascar	Palm
Corypha elata (L.) Roxb.	Southeast Asia	Palm
Daemonorhops periacanthes Miq.	Sumatra	Palm
Dictyosperma alba Wendl.	Madagascar	Palm
Diplothernium caudescens Mart.	Brazil	Palm
Dypsis gracilis Bouj.	Madagascar	Palm
Elaeis guineensis Jacq.	Tropical Africa	Palm
Euterpe edulis Mart.	Brazil, Guyana	Palm
E. oleracea Engelm.	Brazil	Palm
Hyphaene thebaica (L.) Mart.	Tropical Africa	Palm
Kentia sapida Mart.	New Caledonia	Palm
Martinezia corallina Mart.	Martinique	Palm
Maximiliana martiana	Brazil, Guyana, Surinam	Palm
Metroxylon sagu Rottb.	Malaysia	Palm
Oenocarpus bacab Mart.	Guyana	Palm
Oncosperma filamentosa Hume	Iles de la Sonde	Palm
Oreodoxa oleracea Mart.	Barbados, Antilles	Palm
O. regia Kunth	Cuba	Palm
Phoenix dactylifera L.	North Africa, South Africa, Middle East	Palm
P. reclinata Jacq.	Tropical Africa	Palm

Species	Source	Plant type
Phytelephas macrocarpa Ruiz	Colombia, Peru	Palm
Raphia vinifera P. Beauv.	Tropical Africa, Madagascar	Palm
Rhopalostylis sp.	Norfolk Islands, New Zealand	Palm
Sabal palmetto Lodd.	South Florida	Palm
Sagus laevi Rumph	Tropical Asia	Palm
Salacca edulis Reinre	Southeast Asia	Palm
Serenoa repens Small	South Florida	Palm

PANDANACEAE

Pandanus latifolius	Ceylon	Shrub
P. odorus Ridley	Malaysia, Southeast Asia	Shrub
P. polycephalus Lam.	Moluccas	Shrub
P. tectorius L.	Indonesia, Polynesia	Tree

PAPAVERACEAE

Argemone mexicana L.	Mexico	Herb
Papaver syriacum Boiss. et Blanch	Near East	Herb

PARKERIACEAE

Ceratopteris sp.		Herb

PASSIFLORACEAE

Adenia cissampeloides Harms	Africa	Vine
A. venenata Forsk.	Congo, Africa	Vine
Passiflora foetida L.	Pantropical	Vine
P. lunata Willd.	Pantropical	Vine

PEDALIACEAE

Species	Source	Plant type
Ceratotheca sesamioides Endl.	Tropics, South Africa	Herb
Pedalium murex L.	Africa	Herb
Sesamum alatum Thonn.	South Africa & East Asia	Herb
S. angolense Welw.	South Africa, & East Asia	Herb
S. angustifolium Engl.	South Africa, & East Asia	Herb
S. calicynum Welw.	South Africa, East Asia	Herb
S. orientale L.	Pantropical	Herb
S. radiatum Schum. et Thonn.	South Africa, East Asia	Herb

PERIPLOCACEAE

Mondia whitei (Hook. f.) Skeels	Congo	Vine

PHYTOLACACEAE

Giselia pharmaceoides L.	Ceylon	Herb
Mohlana latifolia Miq.	Congo	Herb
Phytolacca abyssinica Hoffmn.	Africa	Herb
P. acinosa Roxb.	East Africa	Herb
P. decandra L.	India	Herb
P. dodecandra l'Her.	America	Herb
P. esculenta van Houte	Guinea Coast	Herb
P. rivinoides Kunth et Bouché	Philippines	Herb

PIPERACEAE

Heckeria peltata Kunth.	Pantropical	Shrub
H. umbellata Kunth.	Southeast Asia	Shrub
Houttuynia cordata Thumb.	India	Herb
Peperomia pellucida (L.) H.B.K.	Pantropical	Herb
Piper auritium H.B.K.	Central America	Herb

Species	Source	Plant type
Piper betle L.	Southeast Asia	Vine
P. stylosum Miq.	Malaysia, East Indies	Herb
P. umbellatum L.	East Indies, Tropical Africa	Herb
PLANTAGINACEAE		
Plantago major L. var. asiatica	Southeast Asia	Herb
PLUMBAGINACEAE		
Statice thonini Viv.	Liberia	Herb
PODOSTEMONACEAE		
Inversodicraea minutiflora	Congo	Aquatic plant
I. sehlechteri Engl.	Congo	Aquatic plant
Podostemon minutiflorus Benth. et Hook.	Africa	Aquatic plant
Sphaerothylax heteromorphe Baill.	Congo	Aquatic plant
POLYGALACEAE		
Carpolobia alba Don	Congo	Herb
C. lutea Don	Congo	Herb
Emex spinosus Campd.	Liberia	Herb
Fagopyrum tataricum Gaertn.	India	Herb
Oxygonum atriplicifolium Mart.	Africa	Herb
Polygala persicariifolia D.C.	Tanzania	Herb
Polygonum barbatum L.	Africa, Madagascar	Herb
P. crespidatum Sieb. et Succ.	Africa, Madagascar	Herb

Species	Source	Plant type
Polygonum glabrum Willd.	Africa, Madagascar	Herb
P. guineense Sch. et Th.	Africa, Madagascar	Herb
P. hydropiper L.	Southeast Asia	Herb
P. minus Huds.	Southeast Asia	Herb
P. odoratum Lour.	South Vietnam	Herb
P. orientale L.	Africa, Madagascar	Herb
P. perfoliatum L.	Southeast Asia	Herb
P. plebeium R. Br.	India	Herb
P. pubescens Blume	Africa, Madagascar	Herb
P. salicifolium Brouss	Africa, Madagascar	Herb
P. senegalense Meisn.	Congo	Herb
P. setosulum A. Rich.	East Africa	Herb
P. tomentosum Willd.	Africa, Madagascar	Herb
Rumex abyssinicus Jacq.	Gabon, Congo	Herb
R. acetosa L.	Europe	Herb
R. ambigius Gren.	India or Near East	Herb
R. bequaertii De Wild	E. Africa	Herb
R. crispus L.	Brazil	Herb
R. dentatus L.		Herb
R. nepalensis Spreng.	Nepal	Herb
R. patientia L.	Senegal	Herb
R. vesicarius L.	Sahara	Herb
Securidaca longipedunculata Frow.	Ethiopia	Tree

PONTEDERIACEAE

Eichhornia crassipes Solms	Pantropical	Aquatic plant
Heteranthera reniformis Ruiz et Pav.	Ceylon, Central America	Herb
Monochoria hastaefolia Presl.	Ceylon	Aquatic plant
M. hastata Solms	Southeast Asia	Aquatic plant
M. vaginalis Presl.	Southeast Asia	Aquatic plant

PORTULACACEAE

Species	Source	Plant type
Calandrina micrantha Schlecht.	Mexico	Herb
Claytonia exigua Torr. et Gray	Chile	Herb
C. perfoliata Donn. ex Willd.	East Siberia & North America	Herb
Portulaca afra Jacq.	South Africa	Herb
P. oleracea L.	South Africa	Herb
P. pilosa L.	South Africa	Herb
P. quadrifida L.	South Africa	Herb
P. tuberosa Roxb.	South Africa	Herb
Talinum arnottii Hook. f.	South America	Herb
T. caffrum Eck. et Zeiyh	South America	Herb
T. patens Willd.	South America	Herb
T. portulacifolium Asck et Schweinf.	South America	Herb
T. triangulare Willd.	Ceylon, Philippines	Herb

PROTEACEAE

Helicia javanica Blume	Malaysia, Southeast Asia	Tree
H. serrata Bl.	Southeast Asia	Tree

RANUNCULACEAE

Ranunculus multifidus Forsk.	Africa	Herb
Thalictrum minus L.	South Africa	Herb

RHAMNACEAE

Colubrina asiatica Brong	Southeast Asia	Shrub
Rhamnus prinoides l'Her	Ethiopia	Shrub
Ziziphus mauritania Lam.	India	Tree

RHIZOPHORACEAE

Species	Source	Plant type
Bruguiera gymnohiza Lam.	Africa	Tree
Rhizophora mangle L.	South Florida	Shrub
R. mucronata Lam.	Pantropical	Tree

ROSACEAE

Rosa damascena Mill.	Java	Shrub
R. moschata Mill.	Java	Shrub
R. multiflora Thunb.	Java	Shrub
Rubus rosaefolius Sm.	Southeast Asia	Shrub

RUBIACEAE

Amaralia calicyna K. Schum.	Congo	
Anotis hirsuta Miq.	Southeast Asia	Herb
Canthium monstrosum Merr.	Africa	Tree
Coffea arabica L.	Ethiopia	Shrub
Cuviera angolensis Walw.	Congo	Herb
C. longiflora Hiern.	Congo	Herb
Dentella repens Forst.	Southeast Asia, India	Herb
Fadogia cienkowskii Schweinf.	Africa, Guinea Coast	
Feretia podanthera Del.	Nigeria	Tree
Geophila obvallata T. Didr.	Africa	Herb
Grumilea ungoniensis K. Schum. et Krause	Africa	
Hedyotis auricularia L.	Malaysia, Ceylon	Herb
H. scandens Roxb.	Central Africa	Herb
Heinsia crinita G. Tayl.	Africa	Tree
H. pulchella K. Schum.	East Nigeria, Sierra Leone	Tree
Morinda citrifolia L.	India	Shrub
M. elliptica Ridl.	India	Shrub
Mussaenda arcuata Poir	Africa	Shrub
M. frondosa L.	India, Southeast Asia	Shrub
M. glabra Vah.	Malaysia	Shrub
M. roxburghii Hook. f.	India	Shrub
M. stenocarpa Hiern.	Congo	Shrub

Species	Source	Plant type
Oldenlandia lancifolia Schuw.	Africa	Herb
O. macrophylla DC.	Ghana	Herb
O. scandens K. Schum.	India	Vine
Paederia foetida L.	Southeast Asia	Vine
P. verticillata DC.	Southeast Asia	Vine
Pavetta crassipes K. Schum.	Africa	Shrub
P. esculenta de Wild.	Congo	Shrub
Pentanisia schweinfurthii Hiern.	Africa	Tree
Petunga microcarpa DC.	Indonesia	Shrub
Pseudomussaenda stenocarpa (Hiern.) Petit.	Congo	Shrub
Pseudospondias microcarpa (A. Rich) Engl.	Congo	Tree
Psychotria kisantuensis de Wild.	Congo	Shrub
Randia octomera Benth. et Hook	Congo	Tree
Ravenia robustior Jum. et Perr.	Africa	Shrub
Rothmannia octomera (Hooker) Fagenrind	Congo	
Rubia cordifolia L.	Southeast Asia	Vine
Sarcocephalus esculentus Afzel.	Africa	Tree
S. orientalis Merr.	Southeast Asia	Tree
S. russeggeri Kotschy	Africa	Tree
S. undulatus Miq.	Southeast Asia	Tree
Spermacoce hispida L.	Southeast Asia	Herb
Tricalysia longestipulata de Wild et Th. Dur.	Congo	Shrub
Vangueria spinosa Roxb.	India	Tree

RUTACEAE

Aegle marmelos L.	India, Indonesia	Tree
Afraegle paniculatum Engl.	Africa	Tree
Acronychia paniculata Miq.	Southeast Asia	Tree
Citrus amblycarpa Ochse	Southeast Asia	Tree
C. hystrix DC.	Southeast Asia	Tree
Erioglossum rubiginosum L.	Southeast Asia	Shrub
Evodia lucida Miq.	Indonesia	Shrub
Fagara leprieurii Engl.	Africa	Tree
F. olitoria Engl.	Africa	Tree

Species	Source	Plant type
Fagara paracantha Milldbr.	Tanzania	Shrub
Murraya koenigii Spreng.	India	Tree
SABIACEAE		
Meliosma pinnata Roxb.	India	Tree
SALICORNIACEAE		
Salicornia arabica L.	North Africa	Herb
S. perrieri A. Chev.	North Africa	Herb
SALVADORACEAE		
Dobera roxburghii Planch	Africa	Tree
Salvadora persica L.	Africa, India	Tree
SANTALACEAE		
Champereya griffithii Hook. f.	Southeast Asia	Shrub
SAPINDACEAE		
Allophylus olnifolius Radlk.	Africa	Tree
Cardiospermum grandiflorum Swartz.	Africa	Vine
C. helicacabum L.	Southeast Asia, India	Vine
Cubilea blancoi Bl.	Philippines	Tree
Mischocarpus sundaicus Blume	India	Tree
Paullinia pinnata L.	Congo	Shrub
Schleichera oleosa Merr.	Southeast Asia	Tree
S. trijuga Willd.		Tree

SAPOTACEAE

Species	Source	Plant type
Achras zapota L.	Mexico, Guatemala, Salvador	Tree
Bassia latifolia Roxb.	Europe, Mediterranean, Australia	Tree
B. longifolia L.	India	Tree

SCROPHULARIACEAE

Artanema angustifolium Benth.	Africa	Herb
Limnophila aromatica Merr.	Southeast Asia and Islands	Herb
L. conferta Benth.	India	Aquatic plant
L. erecta Benth.	Southeast Asia and Islands	Herb
L. indica Druce	India	Aquatic plant
L. roxburghii G. Don	Philippines	Aquatic plant
L. rugosa Merr.	Southeast Asia	Aquatic plant
Striga macrantha Benth.	Sierra Leone	Herb

SEROPHYLARIACEAE

Torenia parviflora Benth.	Congo	Herb

SIMARUBACEAE

Balanites aegyptiaca Del.	Egypt	Tree

SOLANACEAE

Capsicum annuum L.	Worldwide	Shrub
C. baccatum L.	Tropical America	
C. frutescens L.	Worldwide	Shrub
Cestrum latifolium Lam.	South America	Shrub
Lycium chinense Mill.	China	Shrub

Species	Source	Plant type
Nicotiana tabacum L.	South America	Herb
Physalis angulatus L.	Worldwide	Herb
P. minima L.	South America	Herb
P. peruviana L.	Peru, Chile	Herb
Schwenkia americana L.	Africa	Herb
Solanum aethiopicum L.	Africa	Herb
S. bansoense Damm.	Africa	Herb
S. blumei Nees	Indonesia and India	Herb
S. dewevrei Damm.	Africa	Herb
S. distichum Thonn.	Africa	Herb
S. duplosinuatum Klotzsch.	Africa	Herb
S. erythracanthum Dun.	Africa	Herb
S. giorgi de Wild.	Africa	Herb
S. incanum L.	Africa	Herb
S. indicum L.	Indonesia and India	Herb
S. lescrauwaerti de Wild.	Africa	Herb
S. macrocarpon L.	Africa	Herb
S. melongena L.	Africa	Herb
S. nigrum L.	Africa	Herb
S. nigrum var. guineense	West Africa, U.S.	Herb
S. nodiflorum Jacq.	Africa	Herb
S. olivare Baill. et Guiss.	Africa	Herb
S. radiatum Sendt.	Africa	Herb
S. sessiliflorum Dun.	Brazil	Herb
S. subsessilis de Wild.	Africa	Herb
S. terminale Forsk.	Africa	Herb
S. torvum Sweet	Tropical Asia, Southeast Asia	Herb
S. tuberosum L.	Java and India	Herb
S. uporo Dun.	Pacific Islands	Herb
S. wildemannii Damm.	Africa	Herb
S. xanthocarpum Sch. & Wendl.	Indonesia and India	Herb

SONNERATIACEAE

Sonneratia acida L. f.	Southeast Asia	Tree
S. alba Smith	Southeast Asia	Tree

STERCULIACEAE

Species	Source	Plant type
Cola diversifolia de Wild. et Th. Dur.	Congo	Tree
C. gilletii de Wild.	Congo	Tree
Heritiera minor L.	India	Tree
Kleinhovia hospita L.	Philippines, Celebes	Tree
Melochia corchorifolia L.	Pantropical	Vine
Sterculia appendiculata Engl.	Africa	Tree
S. tragacantha L.	West Africa	Tree

SYMPLOCACEAE

Symplocos odoratissima Choisy ex Zoll.	Southeast Asia	Tree

THEACEAE

Camelia sinensis L.	Southeast Asia	Shrub

TILIACEAE

Corchorus acutangulus Lam.	Tropics	Herb
C. capsularis L.	India	Herb
C. olitorius L.	India, Africa	Herb
C. tridens L.	Africa	Herb
C. trilocularis L.		Herb
Glyphaea laterifolia Monach	Africa	Shrub
Grewia carpinoifolia Juss.	Africa	Tree
G. corylifolia A. Rich	Africa	Tree
G. mollis Juss.	Africa	Tree
G. retusa Chiov.	Africa	Tree
G. villosa Willd.	Africa	Tree
Triumfetta annua L.	Africa	Herb
T. cordifolia A. Rich	Africa	Tree
T. gartramia L.	Malaysia	Herb
T. rhomboidea Jacq.	Philippines	Herb

TYPHACEAE

Species	Source	Plant type
Typha angustifolia L.	Africa	Herb
T. capensis Roxb.	Africa	Herb
T. elefantina Roxb.	Africa	Herb

ULMACEAE

Celtis integrifolia Lam.	North America, Africa	Tree
C. luzonica Warb.	Philippines	Tree
Trema guineensis Ficalho	Africa	Tree
T. orientalis Bl.	Southeast Asia	Tree

UMBELLIFERAE

Alepidea sp.	Africa	
Anethum graveolens L.		Herb
Annesorhiza flagellifer Berth. Davy	Africa	
Apium graveolens L.	Worldwide	Herb
A. sowa	India	Herb
Carum carvi L.	Europe	Herb
C. involucratum Baill.	Temperate	Herb
Centella asiatica Urb.	Southeast Asia	Herb
Chaerophyllum bulbosum L.		Herb
Coriandrum sativum L.	Worldwide	Herb
Cryptotaenia canadensis A. DC.	Pantropical	Herb
Daucus carota L.	Worldwide	Herb
Eryngium creticum Lam.	Near East	Herb
E. floridanum Coult.	Central America	Herb
E. foetidum L.	Pantropical	Herb
Ferula communis L.	North Africa	Herb
Foeniculum vulgare Mill.	Pantropical	Herb
Oenanthe anomala Dur. et Coss.	North Africa	Herb
Peucedanum capense Sond. Cf. Apium	Africa	Herb
Petroselinum crispum (Mill.) Nym.	Worldwide	Herb

Species	Source	Plant type
Scandix iberica Biel.	Near East	Herb
Sium sp.	South Africa, East Asia	Herb
Smyrnium olusatrum L.	North Africa, Europe	Herb

URTICACEAE

Boehmeria nivea Gaud.	Indonesia	Shrub
B. platyphylla D. Don	Africa	Shrub
Cudrania javensis Trecul	Southeast Asia, Moluccas	Shrub
Dorstemia sp.	Africa	Herb
Elatostema sp.	Southeast Asia, Philippines	Herb
Fleurya aestuans Gaud.	Ceylon	Herb
F. interrupta (L.) Gaud.	Philippines	Herb
F. ovalifolia Dandy	Africa	Herb
F. podocarpa Wedd.	Ceylon	Herb
Laportea terminalis Wight	India	Shrub
Pilea glaberrima Bl.	Southeast Asia	Herb
P. melastomoides Bl.	Southeast Asia	Herb
Pouzolzia guineensis Benth.	Ceylon	Herb
P. zeylanica Benn.	Malaysia	Herb
Urera cameroonensis Benth. et Hook. f.	Africa	Vine
U. mannii Wedd.	Africa	Vine
U. obovata Benth.	Africa	Vine
U. oblongifolia Benth.	Sierra Leone, Tropical America	Shrub
Urtica dioica L.	North Africa, North America	Herb
U. massaica Mildbr. ex Peter	East Africa, Congo	Herb
U. pilulifera L.	North Africa, North America	Herb
U. urens L.	South and North Africa	Herb
Villebrunea rubescens Bl.	Southeast Asia	Herb

VALERIANACEAE

Species	Source	Plant type
Fedia cornucopiae Gaertn.	Africa	Herb
Valerianella olitoria Poll	Mountainous region	Herb

VERBENACEAE

Avicennia officinalis L.		Tree
Clerodendron minahassae T. et B.	Indonesia	Shrub
C. serratum Spreng.	Southeast Asia	Shrub
Lantana camara L.	Pantropical	Shrub
L. salvifolia Jacq.	Congo	Shrub
Lippia adoensis Hochst.	Congo	Herb
L. graveolens H.B.K.	Tropical America, Africa	Herb
L. helleri	Tropical America, Africa	Shrub
Premna divaricata Wall.	Malay Peninsula	Shrub
P. foetida Reinw.	Malay Peninsula	Shrub
P. integrifolia L.	Indonesia, Thailand	Shrub
P. odorata Blanco	Philippines	Tree
Stachytarpheta indica Vahl.	Pantropical	Herb
S. jamaicensis Vahl.	South America	Herb
Vitex cienkowski Kotsch et Peyr	West Africa	Tree
V. doniana Sweet	West Africa	Tree

VIOLACEAE

Viola abyssinica Oliv.	Africa	Herb

VITACEAE

Cissus barteri Bl.	Congo	Vine
C. dinklagei	Gabon	Vine
C. discolor Bl.	Southeast Asia	Vine
C. petiolata Hook.	Congo	Vine
C. populnea Guill. et Perr.	West Africa	Vine
C. producta Afzel.	Gabon	Vine

Species	Source	Plant type
Cissus pseudocaesia Gild. et Br.	Africa	Vine
C. quadrangularis L.	Africa, India	Vine
C. repens Lam.	Southeast Asia	Vine
Leea aspera Edgew.	India	Vine
L. macrophylla Roxb.	India	Vine
L. quineensis	West Africa	Tree
Tetrastigma harmandii Pl.	Philippines	Shrub
T. lanceolarium Planch.	Tropical and Subtropical Asia	
T. loheri Gagnep.	Philippines	Shrub

ZINGIBERACEAE

Aframomum granum-paradisi K. Schum.	Africa	Herb
A. giganteum K. Schum.	Africa	Herb
Alpinia galanga Sw.	China	Herb
A. officinarum L.	China	Herb
Amomum cardamomum Willd.	Pantropical	Herb
A. citratum Pers.	Pantropical	Herb
A . maximum Roxb.	Indonesia	Herb
Costus phyllocephalus K. Schum.	Congo	Herb
C. speciosus Smith	Southeast Asia	Herb
Curcuma amada Roxb.	Southeast Asia	Herb
C. aurantiaca van Zyp.	Southeast Asia	Herb
C. longa Auct.	Southeast Asia	Herb
C. mangga Val. et van Zyp.	Southeast Asia	Herb
C. xanthorhiza Roxb.	Southeast Asia	Herb
C. zedoaria Rosc.	Southeast Asia	Herb
Kaempferia galanga L.	Southeast Asia	Herb
K. pandurata Roxb.	Southeast Asia	Herb
K. rotunda L.	Southeast Asia	Herb
Languas sp.	Malaysia	Herb
Phaeomeria atropurpurea Schum.	Indonesia	Herb
P. speciosa Kds.	Ceylon, New Guinea	Herb
Zingiber officinale Resc.	Pantropical	Herb

ZYGOPHYLLACEAE

Fagonia sp.	Sahara	Herb
Tribulus terrestris L.	India, East Africa	Herb

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