Germplasm Resources in Vietnam: Major Horticultural and Industrial Crops

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Situated on the east bank of the Pacific Ocean, Vietnam has a diverse ecogeographic range and an unusually high diversity of species. There are two major eco-zones, one in the north with distinct seasonal temperature changes, including a cold winter, and one in the south with typical tropical climate. The dividing line between these zones is at the Hai Van Pass, 16.5°N (Vu-tuyen, 1996). The country is divided into seven major agro-ecozones from north to south: 1) the northern hilly and mountainous region; 2) the Red River Delta; 3) the northern part of the central coast line; 4) the southern part of the central coast line; 5) the central highland; 6) the area northeast of the Mekong Delta; and 7) the Mekong River Delta (Fig. 1) (Vien Quy Hoach va Thiet Ke Nong Nghiep, 1997; Vu-tuyen, 1996). The large and heterogenous zone 1 is further divided into: 1) northern mountainous; and 2) northern midland zones (Nguyen-huu and Ngothe, 1996).

About 40% of the country's plant and animal species are endemic (Government of the Socialist Republic of Vietnam and Global Environmental Facility, 1994). The highest levels of endemism are concentrated in four regions: 1) the Hoang Lien Son Mountains in the north; 2) the humid forest of the northern part of central Vietnam; 3) the Ngoc Linh mountains in the center of the country; and 4) the Lam Vien highlands in the south (Fig. 1) (Tran-dinh, 1996a). The World Conservation Monitoring Center (WCMC) has rated Vietnam as the 16th most biologically diverse country in the world (Socialist Republic of Vietnam, 1992).

There are more than 12,000 native plant species in Vietnam, with ≈10,500 described to date (Pham-hoang, 1991, 1992, 1993). At least 40 crop species have part of their distribution range in Vietnam (Government of the Socialist Republic of Vietnam and the Global Environmental Facility, 1994). The numbers of edible fruit and vegetable species approach 1500, and nearly 2100 species are used as medicines in Vietnam.

This biodiversity has been shaped not only by the geographical and environmental variability of Vietnam, but also by the equally diverse cultures of its more than 50 ethnic groups. The Kinh ethnic group, which constitutes 87% of the population, still practices

paddy rice-based cultivation (Do-dinh, 1994). However, 50 other ethnic groups of ≈9 million people rely on a much more complex array of foods in the mountainous regions of the country. These peoples practice primarily shifting cultivation, except in areas adjacent to the Red

Fig. 1. Agricultural zoning map of Vietnam based on a hand-drawn map from the Dept. of Plant Protection, Ministry of Agriculture and Food Industry, Hanoi, 1994. The provinces and cities were based on 1) an administrative map of Viet nam-Lao-Cam pu chia published in 1993 in Dalat, Vietnam, and 2) a map drawn by the World Bank (Denning and Vo-tong Xuan, 1995). The histograms for precipitations and temperatures were obtained from a geographic map (Socialist Republic of Vietnam, 1988). The centers for endemic plants were derived from maps prepared by the World Conservation Monitoring Centre (Socialist Republic of Vietnam, 1992), the Government of the Socialist Republic of Vietnam, and the Global Environmental Facility (1994).

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River Delta, where the Muong, Tay, Nung, and Thai practice both shifting and paddy rice-based agriculture (Do-dinh, 1994).

The goals of this paper are to describe some of the most important horticultural and industrial crop species that are found in Vietnam and to review how that germplasm is being conserved. Where appropriate, we also list close relatives and note how they are utilized. The Vietnamese common name for the crop is listed in parentheses, following its English name. In our citations of Vietnamese authors, we have separated the last and middle names of each author with a hyphen. We also spell out the authors first name in the literature cited, as is the custom in Vietnam. This helps differentiate one author from another, as there are relatively few Vietnamese surnames.

This paper was stimulated by two visits made by one of us (H.T.L.) to universities and agricultural research institutions in Vietnam under an internship granted by the International Development Research Centre (IDRC) of Canada. The trips were taken in 1994 and 1995 for 2 weeks and 4 months, respectively. Both local scientists and farmers were consulted, including the occupants of two hamlets in the watershed of the Da river in Hoa Binh province of Northern Vietnam (Ban Tat and Ban Yen of the Tay, and the Dao peoples, respectively).

ROOT AND TUBER CROPS

Taro ("Mon" or "So", "Nua" and "Ray")

Taro of the Araceae family plays a particularly important role in marginal areas of northern and central Vietnam, where poor soil, typhoons and floods result in frequent losses of the rice harvest. Pham-hoang (1993) described 95 native species of taro in Vietnam that are found in a diverse range of shaded environments, from rocky mountain slopes to wet valleys and flatlands. The most important food and feed genera are: *Colocasia* ("Mon" and "So"), *Alocasia* ("Ray"), *Amorphophallus* ("Nua"), *Cyrtosperma* ("Ray"). Aroids are also used for medicine in Vietnam, including numerous species of *Lasia* ("Ray Gai"), *Typhonium* ("Bac Ha"), and *Homalomena* ("Thien Nien Kien") (Pham-hoang, 1993).

The most important food species, *Colocasia esculenta* L. Schott. ("Khoai Mon" or "Khoai So" or "Mon Nuoc"), is found wild in northern Vietnam and cultivated countrywide (Pham-hoang, 1993). While it is used primarily for staples, the landraces Mon Trang, Mon Sen, Mon Do Loi, and, particularly, Mon Tim are used to prepare a popular dessert enjoyed by people in the former imperial capital of Hue. A giant wild relative species, *C. gigantea* (Bl.) Hook. f. ("Mon to"), is found in Dinh Quan, South Vietnam.

At least 11 *Alocasia* and seven *Amorphophallus* species are utilized in Vietnam (Pham-hoang, 1993). *Alocasia odora* C. Koch. ("Bac Ha" or "Doc Mung") is popularly cultivated countrywide for its leaf petioles,

which are consumed as vegetables. Four species, *Alocasia macrorrhiza* (L.) G. Don, *A. indica* (Lour.) Kunth., *Amorphophallus konjac* K. Koch., and *A. peoniifolius* (Dent.) Nicols. var. *campanulatus* (Roxb.), are cultivated in northern and central Vietnam. Petioles, stems, and tubers are normally used as animal feed, but are also fit for human consumption if cooked for a long time with lime to remove bitterness and other irritants that cause itchiness. Another edible, wild species of *Amorphophallus* is *A. interruptus* Engler and Gehrm. A giant *Amorphophallus* of an undescribed species is found on the island of Phu Quoc, in South Vietnam, and *A. tonkinensis* occurs in Ha Nam Ninh, Hanoi, and Lai Chau in northern Vietnam; *Cyrtosperma merkusii* (Hassk.) Shott., found wild in swampy areas across the country, has roots that can weigh 70 kg (Pham-hoang, 1993).

The first systematic collection of aroids was made in 1992 by the former Potato and Vegetable Research Center, now the Root Crop Research Center (RCRC) of the Vietnam Agricultural Science Institute (VASI), with technical support from the Centro Internacional de la Papa (CIP) (Truong-van and Nguyen-ngoc, 1996). This taro germplasm was evaluated at selected locations with farmers' collaboration and superior lines were released for wider cultivation. Another 55 taro accessions were collected by VASI in 1994 in Son La, Lai Chau, and Yen Bai provinces, with assistance from the Japan National Agricultural Research Center, the National Institute of Agro-biological Resources (NIAR), and the Osaka Agro-biological Resources Center (Tran-dinh, 1996b). The RCRI currently has 402 taro accessions belonging to 15 genera and 39 species of the Araceae family. Their relative proportions are: 72% *Colocasia*; 20% *Xanthosoma* (an introduced species, native to tropical America); 3.8% each of *Alocasia* and *Cyrtosperma*; 1.8% of *Amorphophallus*; and <1% *Typhonium* and *Schizocasia* (Truong-van and Nguyen-ngoc, 1996).

Yam ("Khoai Tu" and "Khoai Mo")

As with taro, yams play an important role as famine insurance in Vietnam. Pham-hoang (1993) described a total of 39 species of *Dioscorea* in Vietnam, including the important worldwide food crops *D. alata* L., *D. esculenta* (Lour.) Burk., and *D. bulbifera* L. (Hahn, 1995). Several Vietnamese yam species are used by indigenous people for purposes other than food, including medicine (*D. persimilis* Prain and Burk.), botanical pesticides (*D. hispida*), and dyes (*D. cirrhosa* Prain and Burk.). Three Vietnamese species of *Dioscorea* were listed as rare by the WCMC, including *D. dissimulans*, *D. petelotii*, and *D. poilanei*, all described by Prain and Burkill (Socialist Republic of Vietnam, 1992). Seventy-two yam accessions representing 13 species have been collected by the RCRI, and are being maintained in the field, in pots and in vitro. *Dioscorea alata* represents 60% of the accessions collected, while *D. esculenta* represents 24%.

TROPICAL FRUITS

Ensete and Musa bananas ("Chuo")

Vietnam is in the center of the distribution range of both *Ensete* and *Musa* (Simmonds, 1995). Vietnamese germplasm played an important role in the world banana industry, as resistance to Panama wilt disease was found in the Saigon Botanical Garden in 1925 and was used to develop 'Valery', a variety that helped reestablish the banana industry in Central America (Plucknette et al., 1987).

Thirteen species of *Musa* are found in Vietnam, including the two important donors of the A and B genomes, *M. acuminata* Coll. and *M. balbisiana* Coll. (Pham-hoang, 1993). Other notable cultivated species include the so-called hundred-bunched banana, *M. chiloicarpa* Back., which has an extremely long inflorescence that reaches the ground; *M. textilis* Nee., cultivated for its fiber; the short banana *M. nana* Lour. ("Chuo Gia Lun"), which is only 1–2 m tall; and the large-trunked *M. bakeri* Hook. f., which has triangular fruits 4–5 cm in length in a drooping inflorescence (Pham-hoang, 1993).

The most important cultivated species is *M. paradisica*, with at least 45 landraces being grown in southern Vietnam (Pham-ngoc and Pham-van, 1995). One of the most popular landraces is "Chuo Ngu" from the provinces of Dong Nai and Gia Dinh. Chuo Ngu, as its Vietnamese name suggests, was once reserved for the sovereigns. It has small fruits, a thin peel, and sweet flesh that the Vietnamese consider to be tastier than the *M. cavendish* groups grown in South America. Other popular South Vietnam landraces of this species are "Chuo Gia," "Chuo Cao," "Chuo Cao Lua," and "Chuo Tieu Hoa" (Ton-that, 1973). In northern Vietnam, the landraces "Nam Dinh" and the "Hung Yen" are highly esteemed for their aroma and taste (Le-dinh, 1996).

Numerous species of bananas are cultivated as ornamentals across Vietnam. These are: 1) *M. coccinea* Andr. ("Chuo Sen") (*M. uranoscopus* Lour., non Rump.) with red petals, yellow flowers, and little finger-sized fruits; 2) *M. rosacea* Jacq. ("Chuo Kieng" and "Chuo Huong"), which has light green, violet, or yellow petals and green stigmata; 3) *M. ornata* Roxb. ("Chuo Kieng Do"), which has flowers with bright red or orange petals; and 4) *M. sanguinea* Hook. f. ("Chuo Kieng Do"), which has dark red petals and yellow-seeded fruits with red stripes.

Several collections of Vietnamese banana germplasm have been made in the last decade. Over 100 representatives of ABB, BBB and AAB genomes, identified only as South East Asian cooking bananas, were collected in 1994 by the Phu Ho Fruit Crop Research Center (PHFCRC) with assistance from International Plant Genetic Research Institute (IPGRI) and International Network for the Improvement of Banana and Plantain (INIBAP) (IPGRI, 1994). This collection may contain the 20 individuals of five *Eumusa* species mentioned by Le-dinh (1996) as growing wild in Yen Bai, Son La, and Lao Ca. Another 19 accessions belonging

to the wild species *M. balbisiana*, *M. itinerans*, *M. ornata*, and *M. borneensis* were collected in 1994–95 by VASI (Tran-dinh, 1996b).

Citrus—Orange (“Cam”), Lime and Lemon (“Chanh”), Mandarin (“Quit”), and Pummelo (“Buoi” and “Bong”)

Vietnam is in the center of diversity of citrus. While most recent taxonomic treatments of citrus consider the primary species of citrus to be *C. medica* L. (citron), *C. reticulata* Bl. (mandarin), and *C. maxima* [Burm.] Merr. (pummelo) (Scora, 1988), most Vietnamese literature on citrus is based on either Swingle and Reese’s (1967) more complex classification system (Do-dinh, 1996), horticultural groupings (Ton-that, 1995), or other taxonomic characteristics (Pham-hoang, 1992). We will generally follow the designations of Pham-hoang (1992), as his taxonomy is the most comprehensive available for the region.

Pham-hoang (1992) described a total of seven taxa in Vietnamese forests. He gave the native range of five: 1) *C. annamensis* Tan. (“Cam Hoi”) in Phu Hu and Phu Khanh; 2) *C. depressa* Hay. in Quang Tri; 3) *C. macroptera* Montr. var. *annamensis* Tan., which is widespread in Nha Trang; 4) *C. aurantium* L. (the sour orange) on Nui Cam in Chau Doc; and 5) *C. aurantium* sub. *ichangensis* Guill. var. *latipes* Guill., a hybrid of *C. grandis* and *C. reticulata*, in Sapa. The two forest species with unspecified locations are *C. amblycarpa* (Hassk.) Ochs. (“Quit Ta”) and *C. hystrix* DC. *Citrus depressa* and *C. amblycarpa* are notable in that they have few to no spines. *Citrus macroptera* has unusually large fruits (10 cm in diameter), and *C. amblycarpa* has bright yellow, sour fruit. *Citrus hystrix* is thought to be tolerant to flooding.

There are a number of ancient cultivated taxa of citrus grown in Vietnam. Some of these were introduced long ago from nearby regions, or were directly domesticated from Vietnamese relatives. These are: 1) the lime, *C. aurantifolia* (Chrism.) Sw. (“Chanh Ta”) of Malaysian origin, which is popular not only for its juice but also for its spicy leaves; 2) a clementine, *C. nobilis* var. *chrysocarpa* Lamk.; and 3) the mandarins, *C. nobilis* Lour. var. *nobilis*, *C. nobilis* var. *microcarpa* Hassk., and *C. deliciosa* Tan. Seven landraces of mandarin are referred to as “Cam” in South Vietnam, with “Cam Sanh” and “Cam Mat” being the most popular. A seedless “Cam Mat” was discovered in Vinh Long (Pham-ngoc and Pham-van, 1995). Six land races of mandarin are called “Quit,” with the three most popular being “Quit Tieu Hong,” “Quit Tieu Nghe,” and “Quit Duong” (Pham-ngoc and Pham-van, 1995). The species relationships of all these landraces are blurred; however, they fall under the broad umbrella of *C. reticulata* Bl., and originated in the Mekong Delta (Ton-that, 1995).

There are several other important cultivated taxa of citrus with ancient origins. Pummelo, *C. grandis* (L.) Osb. var. *grandis* (“Buoi”), includes the landraces “Nam Roi” in Vinh Long, “Duong Da Lang,” “Duong Hong”

and “Bien Hoa” in Bien Hoa, “Thanh Tra” in central Vietnam (Pham-hoang, 1992; Pham-ngoc and Pham-van, 1995), “Doan Hung” in the Chi Dam district, and “Phuc Trach” in the Ha Tinh province (Tran-dinh, 1996b). Despite its high quality, few plants of “Bien Hoa” are still being cultivated because of its low yields. The citrons include *C. medica* L. sub. *bajoura* Bon. with landrace “Thanh Yen” and *C. medica* var. *sarcodactylis* (Sieb) Sw. (“Phat Thu”) (Pham-hoang, 1992). A sweet orange, *C. sinensis* (L.) Osb. (“Cam”), a South China native and a hybrid of *C. grandis* and *C. reticulata* (Sauer, 1993), is also popularly cultivated. A highly esteemed landrace named “Xa Doai” is grown in Nghe An (Ton-that, 1995).

Other cultivated citrus taxa of recent introduction are grapefruit (“Buoi Dang”) [*C. grandis* var. *racemosa* (Roem.) B. C. Stone, also called *C. paradisi* Macf.], and lemon (“Chang Tay”) [*C. limon* (L.) Burm.f., or *C. medica* subsp. *limon* L.]. The former is a hybrid between *C. grandis* and *C. sinensis* (Sauer, 1993) and the latter a hybrid between *C. medica* and *C. aurantifolia* (Sauer, 1993). Both grapefruits and lemons are cultivated in Dalat. They are not, however, widely consumed (Pham-hoang, 1992). *Citrus limonia* Osb. (“Chanh Hanoi” or “Citron de Canton”) is cultivated in Quang Tri and Lam Dong in Central Vietnam (Pham-hoang, 1992). It may be a hybrid of *C. aurantifolia* × *C. reticulata* (Sauer, 1993) or *C. limon* × *C. reticulata* (Pham-hoang, 1992). Another species related to the Chanh group, *C. limonellus* Hassk., was briefly described by Pham-hoang (1992) as a small tree without spines, but no other information was given.

With support from the National Plant Genetic Network, 185 cultivars of citrus have been collected from 11 provinces in northern Vietnam. Swingle and Reese’s classification (1967) was used and the cultivars were classified into nine species and two forms, including *C. sinensis*, *C. limon*, *C. aurantifolia*, *C. aurantium*, *C. jambishi*, *C. reticulata*, *C. grandis*, *C. paradisi*, *C. medica*, *C. sinensis* × *C. reticulata*, and *Citrus* sp. The *C. grandis* and *C. reticulata* were represented by the highest number of cultivars collected (73 and 46, respectively). The *C. medica* collections include three forms with very different plant shapes: *C. medica* (“Bong”), *C. medica* var. *ethrog* (“Thanh Yen”), and *C. medica* var. *saccodactylis* (“Phat Thu” or “Buddha’s hand”) (Do-dinh, 1996). Landraces of *C. reticulata* fell into nine morphological groups that clustered around their place of origin and exhibited a wide range of fruit ripening dates. The early ones, “Sour” and “Giay” mandarins, are ready for harvest in September or October; the midseason ones, “Tich Giang,” “Dong Khe,” “Dan Ha,” and “Bac Giang” ripen in November and December; and the late ones, “Chun,” “Chum,” “Bac Quang,” “Duong Yen Bai,” and “Cam Sanh” mandarins, ripen in December and January.

Citrus collections are also being maintained at the PHFCRC. According to Le-dinh (1996), 57 accessions of citrus are being main-

tained there. In another report, 48 cultivars, with 170 surviving trees, are listed; these may be the remnants of an original collection of 185 samples (Do-dinh, 1996).

Mango (“Xoai”)

The native distribution of several *Mangifera* species includes Vietnam. The two most common are: 1) *M. foetida* Lour. (“Xoai Hoi” or “Muom”), which is located in both northern and central Vietnam (Do-tat, 1986; Pham-hoang, 1993) and has sour fruits with thin pulp; and 2) *M. caloneura* Kurz. (“Queo” and “Xoai Lua”), which is distributed country-wide in wetlands and has flaming red fruits, as its Vietnamese name denotes. Three mango species are found in central and South Vietnam. *Mangifera dongnaiensis* Pierre, “Dong Nai” or forest mango (“Xoai Dong Nai” and “Xoai Nui”), which is found in wet, submontagne, and evergreen forests along the river Dong Nai south of the Di Linh highlands. The forest mango is distinguished by its long inflorescence of 10–20 cm length, with fruits tilting at its ends. *Mangifera flava* Evr. (“Xoai Vang”) is found in central Vietnam in the provinces of Quang Nam and Phan Rang. It has small (4 cm long), round, and yellow-fleshed fruits, which bulge on their sides. *Mangifera longipes* Griff. or *M. laurina* Bl. (Kosterman and Bompard, 1993) (“Xoai Cong Dai”) is a very large tree (40 m tall) with red wood and sparse inflorescences. Two mango species are endemic to Vietnam. *Mangifera cochinchinensis* Engl. (“Xoai Nut”) is distributed in the provinces of Bien Hoa, Binh Duong, and Thu Dau Mot, near Ho Chi Minh City, and has small fruits ≈3 cm long. *Mangifera minutifolia* Evr., Forest Mango (“Xoai Rung”) or Small Leaf Mango (“Xoai La Nho”), is a medium-sized tree 25 m tall, and is distributed only above 600 m in Phu Khanh, near Nha Trang. *Mangifera cochinchinensis* and *M. flava* are on the endangered list of the WCMC, and *M. minutifolia* is rare and may be at risk (Socialist Republic of Vietnam, 1992).

There are also two species of *Bouea* that should probably be considered as native mangoes. *Bouea oppositifolia* (Roxb.) Adelb. or *M. oppositifolia* Roxb. (“Thanh Tra”) is found in evergreen forests in Chau Doc province and Phu Quoc island. It has egg-sized fruits with a sour taste. *Bouea poilanei* Evr. (“Xoai Mu” and “Xoai Muc”) is found in Trang Bom and has red fruits. Kostermans and Bompard (1993) recently excluded these two species from their latest mango taxonomy; however, they acknowledged that several species from Indochina remain poorly described.

Two mango species are cultivated in Vietnam: 1) *M. odorata* Griff., fragrant mango (“Xoai Thom”), which has fibrous seed and sweet, yellow-fleshed fruits; and 2) *M. indica* L., the most important species worldwide, which was probably introduced by Buddhist monks from India around 4 BC (deLaroussilhe, 1980). Eleven landraces of *M. indica* have been described in South Vietnam. The most important ones are “Xoai Cat Hoa Loc” in Cai Be and Tien Giang; “Xoai Cat Chu” and “Xoai

Thom" in Dong Thap; and "Tien Giang" and "Xoai Buoi" (also called "Xoai Ba Mua Mua"). The last-named is very popular among mango farmers (Pham-ngoc and Pham-van, 1995). Other well-known landraces of *M. indica* found in South Vietnam are "Xoai Tuong," "Xoai Cat," "Xoai Thanh Ca," and "Xoai Com". In northern Vietnam, "Xoai Yen Chau" in Son La is the most esteemed (Tran-dinh, 1996b).

INDUSTRIAL CROPS

Bamboo ("Tre" and "Truc")

Bamboo has played an important role in Vietnamese culture. Most Vietnamese remember the green bamboo trees of their home villages, regardless of where they have settled. Dominant bamboo forests occupy an area of 580,120 ha or 11.4% of the total forest cover in Vietnam, and mixed forest bamboo occupies another 316,271 ha (Vien Kinh Te Sinh Thai, 1994). Bamboos are revered in classical literature, music and folklore and play a critical role in day-to-day Vietnamese life. They are used for their edible shoots, and women earn extra income by collecting bamboo shoots from the forest and selling the dried products. Bamboo is used in building construction, chopsticks, hats, musical instruments, and home furniture, such as chairs and beds. Bamboo forests can produce as much pulp for the paper industry as woody forests, and in much less time; the rotation cycle for bamboo forests is only 3 years (Vien Kinh Te Sinh Thai, 1994).

Pham-hoang (1993) described 18 genera and 97 species of the sub-family *Bambuseae* of the *Poaceae* in Vietnam. There are seven genera that have major economic value—*Arundinaria* ("Sat"), *Bambusa* ("Tre"), *Phyllostachys* ("Truc"), *Dendrocalamus* ("Luong"), *Sinarundinaria* ("Sat"), *Lingnania* ("Dung"), and *Oxytenanthera* ("Le").

Bambusa is the most widespread bamboo genus in Vietnam, occupying ≈80% of the bamboo cover from the lowlands to the highlands (Vien Kinh Te Sinh Thai, 1994). Pham-hoang (1993) lists a total of 27 *Bambusa* species, the most important of which are *B. vulgaris* Schreder ex. Wendl. ("Tre Nha"), *B. stenostachya* Haeckel ("Tre Gai"), *B. procera* Chev. and Cam. ("Tre Lo O"), *B. arundinacea* ("Tre Loc Ngoc"), *B. multiplex* (Lour.) Raeusch. ("Tre Hoa"), and *B. ventricosa* McClure ("Truc Bung Phat," "Truc Dui Ga"). These species are cultivated for the paper and pulp industries and account for 60% to 70% of the raw materials used in the northern provinces of Tuyen Quang, Yen Bai, Vinh Phu, Bac Thai, and Thanh Hoa and the southern province of Song Be (Vien Kinh Te Sinh Thai, 1994).

Arundinaria ("Sat") species occupy ≈15% of the total bamboo forest cover and have a particularly high economic value in the midlands. This genus is used in the pulp and paper industries, in building construction, and for its edible shoots. Some of the most important *Arundinaria* species are *A. sat* Bal. ("Sat"), *A. callosa* ("Sat Gai La To"), *A. griffithiana* Munro. ("Sat Gai La Nho"), and *A. roveli*

Houz. de la Haie ("May Lang") (Vien Kinh Te Sinh Thai, 1994). Rare species listed by the WCMC are *A. baviensis* Bal. ("Sat Bavi") and *A. vicina* King (Socialist Republic of Vietnam, 1992).

Dendrocalamus ("Luong") species are distributed widely along the Truong Son mountain range (Vien Kinh Te Sinh Thai, 1994). Eleven species of *Dendrocalamus* have been described (Pham-hoang, 1993). The well-known "Luong Thanh Hoa" from the southern Thanh Hoa province, *Dendrocalamus membranaceus* Munro ("Luong"), with canes that are very large in diameter (10–12 cm) and height (20 m), is being developed for use in housing and bridge construction. Luong is also grown in provinces of Hoa Binh, Son La, Nghe An, and Ha Tinh in northern Vietnam. *Dendrocalamus patellaris* Gamble ("Giang") is found in dense and mixed forests in the provinces of Nghe An, Thanh Hoa, Tuyen Quang, Vinh Phu, and Lao Cai. Giang produces a high-quality pulp and is used to produce string (Vien Kinh Te Sinh Thai, 1994). In the north, Giang is spread in the middle of roads to be flattened by passing automobiles for use for light construction, such as in fences or huts. *Dendrocalamus flagellifer* Munro ("Buong") produces the largest shoots, and *D. giganteus* Munro is the tallest bamboo (up to 35 m). Other species listed by the Socialist Republic of Vietnam (1992) with no information on their status are *D. poilanei* Cam. and *D. sinuata* (Gamble) Holttum.

Lingnania ("Dung") species are grown in cool climates as border plants in villages of the Dao and Tay. They are highly rhizomatous and have long internodes (40 cm) and fibers. Important species are *L. chungii* McClure ("Dung Nha") and *L. cerosissima* McClure ("Mang Tan") (Vien Kinh Te Sinh Thai, 1994).

Oxytenanthera ("Le") are widespread in areas with dry seasons, such as the West Plateau in the provinces of Ninh Thuan, Kon Tum, and Daklak. They are small plants with a solid stem up to 8 m tall, are drought resistant, and useful as cover and border plants. They also have good edible shoots. An important species is *O. albociliata* Munro ("May Lay" and "May Sot") (Vien Kinh Te Sinh Thai, 1994). Several species for which we have no information on status include *O. dinhensis* Cam. ("Le Nui Dinh") with tasty shoots and *O. poilanei* Cam. (Socialist Republic of Vietnam, 1992).

Phyllostachys species occupy ≈5% of the surface area of bamboo thickets, and are distributed at 700 m above sea level in Cao Bang, Bac Thai, Lang Son. Six species of *Phyllostachys* are found in Vietnam (Pham-hoang, 1993), with the most economically important being *P. pubescens* Houz. de la Haie ("Truc Sao"), which is ≈20 m tall, and *P. bambusoides* Sieb. and Zucc. ("Truc Can Cau"), which is ≈10 m tall (Vien Kinh Te Sinh Thai, 1994).

Sinocalamus ("Mai") species grow in the forest where the ethnic minorities, Tay and Dao, are found. Mai are found in the provinces of Tuyen Quang, Bac Thai, Cao Bang, Lang Son, and Thanh Hoa. They are large bushes,

15–17 m tall and have large, thick-walled canes (15–20 cm) that are used for building construction, water pipes, and water containers. Their tasty, edible shoots are eaten fresh or dried. The most important species are *S. giganteus* (Munro) Keng f., *S. latiflorus* (Munro) McClure and *S. farinosus* Keng et Keng f. (Vien Kinh Te Sinh Thai, 1994).

Coconuts ("Dua")

Vietnam is in the native range of the important coconut species, *Cocos nucifera* L.. Its cultivation is widespread in the South, with its northern limit being the Thanh Hoa province. While coconut still covers a substantial acreage in Vietnam, its area has been greatly reduced from 400,000 ha in 1987 to 250,000 ha in 1995 because of poor prices and a switch to agronomic crops. About 50 diverse landraces were grown in Vietnam a few decades ago, but this number has been reduced to only 10 (Nguyen-van and Phan, 1995; Ton-that, 1974). Several more landraces, "Stripe," "Sweet" (Sweet husk), "Dua," "Sap," "Eo," and "Bi," face extinction in the Mekong delta (Nguyen-van and Phan, 1995). "Dua" is particularly notable for its pineapple fragrance and "Sap" for its high oil level. Little effort has been made to conserve this material.

Sugarcane ("Mia")

Vietnam is in the natural distributional range of at least three species of sugarcane (Roach, 1995). Wild *Saccharum spontaneum* L. is found countrywide, whereas native *S. sinensis* Robx. grows in the provinces of Lang Son and Tuyen Quang in northern Vietnam and the noble cane *S. officinarum* L. is widely cultivated (Nguyen-huy, 1996). Sugarcane is a particularly profitable cash crop in regions near cities. In Hoa Binh province sugarcane is used as a snack in the urban area of Hanoi, costing \$US 0.10–0.20 per cane as compared with \$US 0.20–0.30 per kg for rice (Le-tran Binh, pers. comm.). Sugarcane cultivation requires less labor than does rice cultivation, and growers in this region are assured of higher yields than with upland rice.

Many landraces of sugarcane are cultivated nationwide. One of the oldest sugarcane landraces may be "Mia Lau" (*S. sinensis*), which is cultivated in Quang Ngai, Bien Hoa, and Tan Uyen. It is mentioned in Vietnamese folk poems (Ton-that, 1970).

Within *S. officinarum*, the landrace "Mia Tien" is of particularly high quality, is grown in Thanh Hoa, and was once reserved for the sovereigns. In Phu Yen, Khanh Hoa, and Ninh Thuan, the landraces "Thanh Dieu" and "Mia Mung" are grown, with notably soft, sweet, juicy, and fragrant stems (Nguyen-huy, 1996). Many landraces of *S. officinarum* were introduced in the early 20th century by the Indochina Agricultural Directorate; these include "Mia Son," "Thom," "Dieu" ("Black Cheribon" or "La haine purple"), "Mia Khoan Co" ("La haine striped"), "Mia Trang," "Mia Voi," ("Tanna"), "Mia Vang" or "Vang Tay" ("Yellow Caledonia") "Mia Mung," "Mia Tre," and "Mia Xanh" (Ton-that, 1970).

Considerable work has been done in evaluating sugarcane lines in Vietnam. Ton-that (1970) observed that *S. spontaneum* and *S. sinensis* are not resistant to the black smut fungus, *Ustilago scitamines* Sydow. However, some strains of these two species are very resistant to root rot caused by *Pythium* sp. and some strains of *S. spontaneum* are very resistant to *Collectotrichum falcatum* (*Physalospora tucumanensis* Speg.). A total of 500 accessions were evaluated at the Center for Research in Sugarcane, with 250 from Vietnam. The Vietnamese and Chinese lines had among the largest stem diameters, while Taiwanese lines had the highest yield. Cuban lines had the highest sugar content and the strongest resistance to smut. Indian lines were most drought resistant, vigorous, had high stem numbers and high sugar content. Crosses have been made among these materials and the elite commercial lines of *S. officinarum*, and seven cultivars have been released in the last decade (Nguyen-huy, 1996).

Tea ("Che")

Pham-hoang (1991) described 29 *Camellia* sp. found countrywide. Within *C. sinensis*, the major species of commerce, he described four variants grown in Vietnam: 1) *bohea* (L.) Pierre; 2) *viridis* (L.) Pierre; 3) *assamica* (Mast.) Pierre; and 4) *cantonensis* (Lour.) Pierre. Although the major variant, *C. sinensis* var. *sinensis*, is not found in Vietnam, the Vietnamese variants *bohea* and *viridis* may be hybrids of var. *sinensis* and var. *assamica*, a Vietnamese native.

Tea plays an important role in Vietnamese life. It is prepared fresh or as a processed product scented with lotus or jasmine. In fact, the highly esteemed Sri Lankan tea, cultivar TRI 777, thought to be introduced to Vietnam in 1978, is actually a native of Vietnam. It was introduced to Sri Lanka in 1935 (Nguyen-dang, 1995). Further, the Chinese tea of Vietnamese origin, *C. sinensis* var. *bohea*, is currently being cultivated in Quang Tri, Central Vietnam, and is called "Tuoc Thiet" or "Tra Moc Cau" (Sparrow's tongue tea) (Lien Hiep Cac Hoi Khoa Hoc va Ky Thuat, 1996).

Tea plantations are numerous in the northern highlands, the midlands and the West Plateau of South Vietnam, with a total harvest area of 70,800 ha in 1996, up from 41,600 ha in 1985. Tea exports brought \$US 15 million in revenue for Vietnam in 1995 (Food and Agriculture Organization, 1997); however, there is currently an oversupply of tea in the world market because of reduced tea consumption in developed countries (Ellis, 1995).

While *C. sinensis* is used solely as a stimulant, most of its numerous relatives are used as ornamentals. The strikingly elegant Hoa Hai Duong (*Camellia* sp.) is used to decorate northern Vietnamese homes during the New Year celebration. The fragrant, bright-yellow flowers of *Camellia* sp. from the Cuc Phuong National Park have been used in ornamental breeding in France (Hoi Hoa Lan Cay Canh, 1995). Other native relatives, such as *Schima wallichii* (DC) Korth. sp. *noronhai* (Bl.)

Bloemb., found in high mountains, contains saponin, which is used as fish poison (Pham-hoang, 1991).

FINAL THOUGHTS

Vietnam is well-endowed with native germplasm of horticultural staple and industrial crops. It is also blessed with creative indigenous populations who still work the land for their survival. Vietnamese, after many years of war and isolation, have proved to themselves and the world that they are not only resilient but are quick to develop new innovations and adopt others. Their success in becoming a rice exporter again, using introduced cultivars from the International Rice Research Institute (IRRI), is an excellent example of how rapidly new technologies, related to food security, have been successfully applied given an agricultural policy that provides incentive to farmers.

Native germplasm of fruit, vegetable and spice crops are precious genetic resources with tremendous potential for further development in Vietnam, both for internal use and as export commodities to other parts of the world where these crops are important. The native germplasm described above holds the key to sustaining food production while conserving the environment. Many species can be used as nontraditional forms of agricultural income and can be grown in mountainous and deforested areas. Unfortunately, much of the native germplasm is being ignored or displaced by introduced, high-yielding varieties, new crops, and population pressure. Policies and technologies that are conducive to the conservation and breeding use of germplasm are essential.

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