Harvest Security and Intraspecific Diversity in Traditional Tropical Agriculture[1]

DAVID L. CLAWSON[2]

The horticultural strategies of traditional tropical agriculturists center on the preservation of harvest security. In addition to cultivating simultaneously numerous species of crops, traditional tropical farmers also plant multiple varieties of each crop. These cultivars are frequently distinguished on the basis of color, ranging from white to yellow to red to purple. In addition to varying in appearance and taste and in resistance to environmental stresses, the color-based varieties often differ in length of growing season. By practicing multicolored, intraspecific polyculture, the traditional tropical farmer either provides himself several opportunities to secure a complete single harvest and/or staggers his harvest throughout the year and thus, in either case, preserves his lifestyle. Acceptance of Green Revolution technologies by traditional tropical farmers would accelerate if they were offered multiple, high-yielding varieties of staple food crops of varying color and maturation periods.

It is generally recognized that traditional tropical farmers cultivate a great variety or diversity of crops in order to maximize harvest security within the confines of the limited space available to them (Anderson, 1952; Chang, 1977; Igbozurike, 1971; Colson, 1979). In the Congo Basin, for instance, "it is not uncommon for a farmer to grow thirty or more different crops—and as many as sixty are recorded" (Miracle, 1967, p. 283). Nearly 90 cultivated species of edible plants were identified in the garden of one home near Tuxtepec, Oaxaca, Mexico (Ewell and Poleman, 1979, p. 61). A typical plot will include a mix of grains, tubers, legumes, cucurbits, and even "tree" crops such as papaya and bananas all blending together in a seemingly chaotic explosion of growth. This type of agriculture, patterned in its structure and composition after the tropical rainforest environment, focuses on *interspecific* diversity.

It is less understood, however, that the traditional, small-scale tropical farmer generally practices *intraspecific* polyculture in addition to interspecific multiple cropping. This is accomplished by cultivating numerous cultivars of the same staple crop in the same plot or in neighboring fields.

The purpose of this study is to illustrate the utilization by traditional tropical farmers of the varying maturation periods of multicolored cultivars of staple food crops as a harvest security mechanism. The practice of intraspecific polyculture constitutes an invaluable, practical supplement to current efforts to preserve in gene banks the dwindling germplasm resources of the world's food crops (Plucknett et al., 1983; Brown, 1983; Fischbeck, 1981; National Academy of Sciences, 1972). It also suggests alternate strategies for the development and diffusion of Green Revolution technologies among traditional Third World farmers.

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[1] Received 19 August 1983, accepted 5 July 1984.

[2] Department of Anthropology and Geography, University of New Orleans, New Orleans, LA 70148.

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COLOR AND INTRASPECIFIC VARIATION

Varietal differences frequently manifest themselves in varying maturation periods. By cultivating as many varieties as possible of a given crop, the traditional farmer can either provide additional opportunities to reap a respectable single harvest, or he can extend, in effect, the growing and harvest periods, or do both, and in either case hopefully insure that if some of the varieties produce poorly, the others will be less affected and the overall harvest will prove adequate to sustain life.

Varietal variation is preserved in nature through a wide array of slight physical differences. The majority of these, while recognizable to the naked eye, are not visually obvious. To the uneducated, yet intelligent and creative traditional, tropical agriculturist, color differences constitute one of the most distinctive and readily observable indicators of variation in food plants (Harlan, 1975). Patiño (1963, p. 105) concluded that color was formerly so dominant in varietal differentiation among Latin American peasants that "it is almost exclusively by color that some varieties can be identified in the colonial literature." Even today, he continued, "in the language of superstitious natives, the names of the varieties are merely the word used to express the corresponding color."

The existence of plant color variation within tropical agriculture has been studied from numerous perspectives. Botanists, biologists, and members of related disciplines have analyzed the chemical cycles and functions of plant pigments while stressing their value in attracting seasonal insects and other animal agents of pollination and dispersal (Hill, 1952; Cox et al., 1973). Conversely, social scientists, including anthropologists, cultural geographers, and rural sociologists, have emphasized the utilization of plant products of varying colors in the religious, mythological, dietary, and medicinal customs of traditional peoples (Spicer, 1967; Stone, 1975; Malinowski, 1965). Both viewpoints, however, have largely failed to focus on perhaps the most fundamental function of intraspecific diversity in small-scale tropical agriculture—the assurance of human survival through the cultivation of multiple varieties of staple food crops of varying color and maturation periods. The remainder of this study, organized by broad crop categories, provides a selective analysis of this practice among traditional agriculturists.

GRAIN CROPS

Maize

The selective cultivation of multicolored cultivars of maize from among the estimated 200–300 varieties (Beadle, 1980) extant in the New World at the time of the Iberian conquest was amply documented by early Spanish chroniclers. Columbus himself recorded finding, upon his arrival at the Venezuelan coast in 1498, "among the natives white, violet, and red maize" (Patiño, 1963, p. 112–113). The utilization of the color varieties for their varying maturation periods was suggested by the Spanish historian Arellano Moreno who described 2 varieties cultivated in the vicinity of Barquisimeto, Venezuela, in 1579, "one which yields in forty days and the other more or less in three months" (Patiño, 1963, p. 111). Early colonial accounts of maize culture in Popayán, Colombia, noted that the preferred variety required the better part of a year to mature (because of the

TABLE 1. USES OF COLOR VARIETIES OF MAIZE, NEALTICAN, MEXICO.

Kernel color	Approx. length of growing season (mo)	Relative yield	Desirability of taste and texture	Most common use
Yellow	6½	highest	lowest	animal feed
White	6	high	high	human food
Blue-purple	5	moderate	highest	human food
Red	4½	low	low	reserve human food

relatively high elevation) and was called (and still is known as) *maíz de año,* or year-long maize. There was also a second variety that matured in 3–4 mo and was given the name *matahambre,* which translates as "hunger or famine killer," owing to its ability to produce a quick harvest and stave off hunger (Patiño, 1963, p. 123–128).

In previous research, I have analyzed the role of multicolored Indian maize (*Zea mays* L.) within current Mexican traditional agricultural systems (Clawson and Hoy, 1979). In the highland Puebla village of San Buenaventura Nealtican, 4 strains or varieties of maize are cultivated extensively. These cultivars are distinguished by yellow, white, blue-purple and red kernel color. Yellow maize is perceived by the local farmers as the highest-yielding variety but is also considered to have a bad taste and, consequently, to be fit only for animal feed (Table 1). Poverty, however, and the attendant emphasis on human rather than animal food production, has led most farmers to feed their few animals dried cornstalks and wild herbs rather than grain. This practice, in turn, has resulted in very little yellow maize being cultivated by the villagers.

White maize is considered good tasting and constitutes the basis for human diets in the region. It is sown around the middle of April, about a month before the expected arrival of the first summer rains. It is a slow-maturing variety and is not ready for harvest until approximately 6 mo have elapsed and the October–April dry season has begun.

The peasant farmer will inspect his field 2–4 wk after he has sown his white maize, when the young plants are 4–6 cm high. He often finds that, for varying reasons including poor seed, microclimatic and soil factors, and insect, bird, or rodent damage, the maize has germinated unevenly. Rather than allowing part of his land to remain unproductive, the farmer will replant the barren sections with blue-colored maize. The blue is considered superior in taste to the white but its yields are lower. Its greatest asset, however, is that it has a maturation period 2–4 wk shorter than that of the white maize. The blue maize will thus mature fully in a shorter growing season and will be ready to harvest at the same time as the white maize with which it shares a field. If, by some serious misfortune, part of the blue maize also fails to germinate, the peasant will turn as a last resort to his red maize, which is considered inferior in both taste and yield to all other varieties but which also has the shortest maturation period. It, too, will ripen before the aridity and cold of fall bring an end to the growing season. Multicolored maize in Nealtican thus functions, in a very literal sense, as a crop insurance and life-protection mechanism.

The use of colored maize varieties of varying maturation periods remains widespread throughout rural Latin America. Wassen (1949) stated that the Cuna of Panama cultivated close to a half-dozen varieties identified by color. Stone (1975) noted 12 cultivars among the Boruca of Costa Rica. Parsons (1968) and Portal (1970) have reported similar findings in Colombia, as have Johannessen (1982), O. Horst (pers. comm.), and Anderson (1952) for Guatemala. In all instances, light-colored varieties were generally associated with long growing seasons and dark-toned cultivars utilized for their short growing seasons. Faced with potential hunger or starvation, the self-reliant Latin American peasant has devised an ingenious system, based on the genetic variation of his staple subsistence crop, to maximize his chances for survival.

Millet

In addition to reliance on multicolored cultivars of a single grain crop, such as maize in Latin America, small-scale tropical agriculturists often cultivate together multiple cultivars of varying maturation periods of two or more grain crops in their efforts to achieve the greatest possible degree of harvest security. This strategy is well-documented among millet farmers of tropical Africa. David (1976) has noted that the Massa of northern Cameroon cultivate 5 varieties of pearl millet, *Pennisetum americanum* (L.) K. Schum., and 4 varieties of the crop are sown among the neighboring Matakam tribe. He further observed that millets "have long been cultivated with sorghum for variety and an insurance against a poor rainy season" (p. 249). Scudder (1976) reported the same practice of mixed intraspecific and interspecific grain-crop diversity among the subsistence farmers of Zambia.

Porteres (1976, p. 428) described what he termed "the common and rather curious practice" in the Mali region of Africa of sowing, for human consumption, multiple varieties of fonio or fundi millet (*Digitaria exilis* Stapf.). Those are followed, in turn, by plantings in the same fields of fast-growing "animal" millet (*Brachiaria deflexa* C. E. Hubbard var. *sativa* R. Port.), which requires, depending upon the variety, from 90–130 days to mature. The result is that "everything arrives at maturity at the same time." Harvest security for both man and beast is thus maximized through simultaneous reliance on both the interspecific and intraspecific genetic resources of the farmers.

Rice

The practice of cultivating multiple rice varieties of varying maturation periods is widespread among small-scale tropical agriculturists. Harris (1976) has observed subsistence farmers of West Africa cultivating both white *Oryza sativa* L. rices of Asian origin and the reddish-brown *O. glaberrima* Steud. African varieties in the same plots. The Kotoko of northern Cameroon cultivate numerous varieties of wild African rice, *Oryza barthii* ex *breviligulata,* with Asiatic strains (David, 1976). The so-called "black rice" that is grown and harvested together in fields with true rices from Guinea to Indonesia is actually a millet, *Paspalum scrobiculatum* L. (de Wet et al., 1983; Harlan et al., 1976). There are, however, documented cases of black-colored rice varieties. Hickey's analysis (1964) of Vietnamese agriculture, for example, noted that in one village 5 cultivars of "hasty," or early-maturing *O. sativa* var. *indica* were cultivated along with 9 late-maturing *indica* cultivars as well as 6 cultivars of *O. sativa* var. *japonica* of which one was yellow-colored and another black. Some 20 cultivars of rice were thus harvested annually by the farmers of the village. In general, native varieties of rice in the tropics are highly photosensitive and vary from 5–9 mo in their maturation periods (Webster and Wilson, 1966).

A strategy, called *décrue,* is practiced along the Niger River, particularly in the "inland delta" of Mali where the rising and falling of the river provide rhythm to the agricultural cycle. Prior to the flood, varieties of lowland or wet rice "are selected according to the anticipated depth of the flood waters, the shorter stemmed forms being planted in the higher fields and the 'floating' varieties . . . in the lower fields subject to deeper flooding" (Harris, 1976, p. 327–328). Each variety matures at a distinct time and is harvested as the flood waters gradually recede. Once the rice has been harvested, sorghum and millet are sown in the fields as dry-weather crops (Harlan and Pasquereau, 1969).

TUBER CROPS

Potatoes

When the Spanish conquistadors invaded the Andean highlands of the Inca empire, they found the natives dependent upon 2 species of potato, *Solanum tuberosum* L. and *Solanum andigenum* Juz. et Buk. (Salaman, 1949). The former is a long-day species while the latter requires short days for normal development and is thus ideally suited to high altitudes of the low latitudes.

Many of the early Spanish chroniclers recorded the cultivation of white, yellow, red, and purple varieties of *S. andigenum* at the time of the Conquest (Patiño, 1963). That these were utilized for their different maturation periods is suggested by the report of Vicente de Oviedo of the cultivation of 2 types of potatoes in the mid-18th century; creole, which "are faster to produce and taste better," and "others called 'turmas de año,'" or year-long potatoes (Patiño, 1963, p. 79).

Thousands of clones of seemingly every color and shape continue to be cultivated on miniscule patches of rocky, steeply sloped Andean land (Parsons, 1968; Correll, 1962; Basile, 1974). Hawkes (1947) identified over 1,000 potato names in use among traditional Andean farmers. The lowest taxonomic level in native classification is the subvariety that is based principally on variations in tuber color. The preference of the highland cultivators for heavily pigmented potato varieties may reflect a greater resistance of the dark-skinned tubers to turning green and bitter in the intense mountain sunlight (Brush et al., 1981).

Traditional potato farmers of highland Mexico cultivate tubers ranging in color from white to purple and, in order to retard the spread of fungal pathogens, often sow 2 or 3 cultivars in a given hill. Planting takes place from January through March with harvesting occurring from September through January (Ugent, 1968). Farmers of Uchucmarca, Peru, identify roughly 35 varieties of potatoes. These are distinguished on the basis of yield, color of skin, relative number of eyes, color of flesh, dry or moist texture of the meal, speed of cooking, resistance to frost and late blight, storage properties, altitude for optimum growth, and length of growing season, the latter varying roughly from 4–8 mo. "Most villagers seem to be able to pull out somewhat over twenty-five varieties from the potato storage piles in the lofts above their houses" (Brush, 1977, p. 171).

Sweet potato

The existence and utilization of multicolored varieties of varying maturation periods of *Ipomoea batatas* (L.) Lam. is widely documented. Over 580 varieties have been classified with both the external and internal root colors occurring in varying shades of white, yellow, orange, red and purple (Yen, 1974, p. 174, 213). Massal and Barrau (1956) cited low altitude maturation periods in the southern Pacific basin of 3–7 mo.

The Ifugao of Luzon "claim more than 200 varieties by name" (Yen, 1974, p. 235). Barrau (1958, p. 89) described the simultaneous cultivation of a 3-mo, white-fleshed "Okinawa" variety with a yellow-fleshed, 4-mo cultivar in Melanesia. A detailed account of the use of color varieties in Latin America was provided by Pedro Martín de Angleria who, in 1944, described an area of South America where 9 varieties were cultivated, including white skin with white flesh, white skin with purple flesh, purple skin with white flesh, purple skin with purple flesh and yellow skin with yellow flesh (Patiño, 1963, p. 63).

In a Vietnamese village, 2 color varieties are cultivated, purple skin with purple flesh and white skin with white flesh. The purple sweet potatoes are preferred both for their flavor and for their shorter maturation periods. The quality of both color varieties also varies according to the season when grown. Those produced during the dry season from October to March are considered sweeter and of higher overall quality than those grown during the summer monsoon months (M. Nguyen, pers. comm.).

The shallow-rooting habit of sweet potatoes is particularly conducive to the employment of partial harvesting as an additional harvest-security mechanism. Subsistence farmers frequently dig only a few tubers at a time from a plant, thereby allowing for the continued growth of the remaining tubers and the development of new ones. Partial harvesting, combined with the volunteer growth of new plants from old or overlooked tubers, permits the small-scale agriculturist to harvest continually a given patch for 2 yr or more (Yen, 1974, p. 72–73).

Cassava

Manihot esculenta Crantz is the only domesticated species of its genus and is believed to have been domesticated in the lowlands of northeastern South America or of Mexico and Guatemala. The tuberous roots contain varying amounts of toxic cyanogenetic glycoside, or prussic acid. Those plants that have little or where it is concentrated in the rind, which is removed in peeling, are termed "sweet," while those with higher amounts (generally 100 mg/kg and over) are called "bitter" and require special processing prior to consumption (Moran, 1975). The acid is freed and released harmlessly into the air by soaking the roots in water and then heating them to 150°C or higher.

Varietal differentiation was formerly made on the basis of the extent of "tuber" toxicity. Sweet varieties were called *M. aipi*, *M. dulcis* or *M. palmata* and bitter ones *M. utilissima*. It is now recognized that toxicity is not correlated with morphological plant features and that it often varies with soil and climatic conditions and the age of the plant. All varieties are now considered to belong to *M. esculenta*.

Color variation in cassava occurs in each of the 3 basic plant organs. Cassava stems vary from silver-grey to greenish-yellow to shades of green and red as well as dark brown and purple-streaked. Leaves are found in solid and variegated green, yellow, and red. The core of the "tubers" is usually white but also occurs in yellow and faint red while the color of the outer cork varies greatly from white to pink and red to light and dark brown and purple (Pérez-Arbelaez, 1956; Purseglove, 1968).

The earliest varieties produce a crop within 4–8 mo after planting but most cultivars are not dug until 10–12 mo (Jones, 1959; Pérez-Arbelaez, 1956). One of the greatest assets of manioc in small-scale tropical agriculture is its ability to continue to grow and store well in the ground following the initial harvest of some of the "tubers." Many varieties keep without serious deterioration and even continue to grow, for up to 3–4 yr. Generally, however, the older the roots, the more woody and acidic they become (National Academy of Sciences, 1975; Purseglove, 1968). Ironically, the roots keep very poorly once dug and generally begin to rot within 48 h of harvesting.

Cassava is thus, perhaps, suited more than any other staple tropical crop to the security needs of the traditional farmer. This attribute, when combined with its superb ecological ruggedness, including tolerance to drought, weeds, pests, and soils ranging from a pH factor as low as 5.0 to as high as 9.0, accounts for its emergence in the 20th century as the dominant "tuber" crop of the tropical world.

By cultivating multiple varieties of cassava, the agriculturist virtually assures his survival. The islanders of Yap raise 20–25 varieties of manioc (Barrau, 1961). The Jivaros of South America cultivate 15 varieties of the root, which they call *mama* (Patiño, 1963). Manioc harvesting in Melanesia occurs at between 5 and 12 or more months after planting, depending upon the variety (Barrau, 1958). In Nigeria, traditional farmers distinguish cassava varieties on the basis of the color of the plant stem, plant growth habit, expected yield, ease of root preparation, and the supposed sex of the plant (Jones, 1959). Luvale tribesmen of the Congo Basin plant their most highly prized cultivars in October, a second group in April, and those varieties of least value in late May or early June (Miracle, 1967). A quote from G. Sautter concerning the Niari Valley Bakamba tribe of the Congo Basin provides an excellent summary of cassava cultivation among traditional African farmers:

> It is impossible to determine the exact duration of its growth. Certain varieties, planted in October–November, are ready for consumption in May or June at the beginning of the long dry season. Others planted at exactly the same time can be harvested only after a year and some months, at the end of the following little dry season. But always, or almost always, many varieties are mixed in the same field and because of this the harvest is staggered over a long period of time (Jones, 1959, p. 135–136).

Yams

The yam, *Dioscorea,* is a tuber primarily of African origin, with some varieties indigeneous to Asia and America. It is noted as a staple carbohydrate source throughout the humid tropics but is least dominant in America and is gradually giving way to cassava in Africa, Asia, and the Pacific Islands. Six hundred species of yams have been identified but the bulk of human consumption comes from ten: *D. rotundata* Poir., *D. cayenensis* Lam., *D. dumetorum* Pax., *D. hispida* Dennst., *D. alata* L., *D. esculenta* (Lour.) Burk., *D. bulbifera* L., *D. opposita* Thunb., *D. japonica* Thunb., and *D. trifida* L. f. (Coursey, 1967, p. 2–3).

D. alata, the so-called greater yam, is also known as the 10-mo yam and sometimes incorrectly as the white yam. It is native to southeast Asia and presently is the most widely grown yam species in the world. In some cultivars, the flesh of the tubers is colored purple by anthocyanin, which, depending upon the amount present, produces anything from pink- to purple-colored flesh. *D. trifida* is the cush-cush yam, or India yam, native to northern South America and is in wide use throughout the Caribbean. The color of its numerous cultivars may be white, yellow, pink or purple (Smole, 1976; Coursey, 1967). The flesh of *D. piscatorum* Prain et Burk. is red whereas that of *D. semperflorens* Uline is violet. Cultivars of *D. rotundata* and *D. cayenensis,* the dominant species of west Africa, both include yellow and white varieties although the former is frequently described as white and the latter as yellow (Coursey, 1967, 1975).

Yam tubers function as organs of dormancy in the plant, surviving but not growing during stressful dry periods. Yam growth is thus highly seasonal and the maturation period of the various cultivars is closely linked to the length of the rainy season. This, perhaps, is one of the principal reasons for the increasing preference of tropical farmers for the more flexible cassava whose production is not seasonal. Because yams require abundant moisture to grow well and are not produced under irrigation, selection of yam varieties is based on their water requirements and relative drought tolerance, with those requiring the longest maturation periods being grown in regions of shortest dry seasons. Beyond this regional variation:

> Some spread of the crop may be achieved by growing several varieties, some of which mature more quickly than others. This can be done particularly well in the wetter districts, with short dry seasons, and can be combined with early and late planting (Coursey, 1967, p. 87).

This same practice, common in Africa, is also followed in southeast Asia. Hickey (1964) observed the intercropping of both red-colored *D. alata* and nonred *D. esculenta.* Rappaport (1967, p. 260) noted "at least thirty-eight named varieties of *Dioscorea* in five different species grown in Tsembaga gardens." Codrington (1969) identified 80 varieties on the Melanesian island of Mota.

Farmers of the village of Free Hill, situated in the rainy highlands of St. Ann Parish in northeastern Jamaica, cultivate yellow, white, and purple-fleshed varieties of the cush-cush yam (D. Clawson, unpubl.). The value and function of each color cultivar is based primarily upon the perceived "hardness" of the tubers rather than on differences in yield or taste. The yellow cultivar is judged the hardest and its 9-mo maturation period is the longest of the 3 varieties. The white-fleshed cultivar matures at 8–8½ mo and is also classified as hard. In contrast to the light-colored cultivars, the dark-fleshed purple (called blue by the local farmers) yams are valued for their ability to produce a crop in only 6 mo. They are perceived, however, as inferior in overall quality because of their softness. Softness is advantageous in cooking because less time and fuel are required to prepare the food. More importantly, however, the softer purple cultivars deteriorate much sooner in ground storage than do their harder yellow and white counterparts and are therefore less valuable for subsistence survival purposes.

Cocoyams

The cocoyam, *Xanthosoma,* was introduced during the colonial period from the American to the Old World tropics where it achieved extensive usage, particularly in West Africa, before declining in recent times in the wake of the expansion of cassava cultivation. Today, some 30–40 species are cultivated, primarily in the low to medium altitudes of the Caribbean islands and the neighboring American mainland regions. Varieties range in maturation period from 3–10 mo (National Academy of Sciences, 1975).

The Free Hill, Jamaica, farmers, referred to previously, cultivate red- and white-fleshed cultivars of *X. sagittifolium* (L.) Schott (D. Clawson, unpubl.). Both color-based varieties require 6 mo to mature but the red (which is frequently called black) is regarded more highly owing to its superior hardness and resultant longer ground-storage life. The white-fleshed cocoyams produce larger tubers and are consequently perceived as higher yielding than the red. By utilizing both the red and the white-fleshed cultivars, the farmers achieve an acceptable balance of security and yield. Both cultivars will generate new plants from the undug corms left from the previous growing season, thereby assuring a continuous, or near continuous, food supply throughout the year.

BEANS

The genus *Phaseolus* consists of approximately 150 species of which two, *P. vulgaris* L., the common bean, and *P. lunatus* L., the lima bean, are cultivated widely by traditional tropical agriculturists. Both species occur in nearly every conceivable color, size, and length of growing season. Color varies not only by seed testa, but also by pod when ripe, leaves, stem, and flowers (Smartt, 1969; Vavilov, 1951). Throughout much of the tropics, beans are grown for the dried fruit rather than to be eaten in the tender pod stage. Consequently, all varieties sown are left to dry until the end of the growing season and maturation period differences are utilized, much as maize and other grains, as a means of ensuring a complete harvest.

In cooler, highland zones, one advantage of sowing multicolored beans is the uneven germination rates of different seeds. Since the arrival and frequency of the early summer rains is generally erratic, traditional farmers, by planting seeds of differing color, can better assure the survival of some of the varieties and thus increase the level of harvest security. Kaplan (1981) found little difference in germination periods among color varieties at 31°C, but at both 16° and 21°C noted that white, bay, and black varieties consistently germinated faster than red or tan-colored cultivars. The continued popularity of black or dark-coated beans throughout Latin America may be attributable in part to higher germination rates and to greater resistance to bean weevil (Berglund-Brücher and Brücher, 1976), as well as to taste and aesthetic considerations.

While not differing in seed characters, climbing beans tend to have a longer maturation period and significantly higher yields than bush forms (Kaplan, 1981; Gentry, 1969). Owing, perhaps, to the greater yields of the climbing forms and also to the adequate supply of cropland prior to the conversion of much of it into pasture by the Spaniards and Portuguese, pre-Columbian American Indians cultivated mostly vining bean forms (Clawson and Crist, 1982; Patiño, 1963). Bush forms have become increasingly dominant in recent times owing to their shorter, more uniform maturation periods and reduced space requirements, qualities well suited to plow agriculture.

Parsons (1968) collected 40 bean varieties in Antioquía and Caldas and noted that the bush forms were called *cuarentanos* from the belief that they mature in 40 days (actual average was 60–90 days) and that the climbing forms, called *bejucos,* required as long as 6 mo to mature. He further observed that the rapidly maturing bush forms tended to be dark colored, especially red, while the later-maturing, climbing beans were lighter toned with yellows predominating. By utilizing both the early, dark-colored bush cultivars and the light-colored climbing beans, a farmer can distribute more evenly his harvest labor requirements as well as provide increased security for his family. Similar advantages are realized by farmers of the high country around Lake Kivu, Africa, who cultivate as many as 10 varieties of *P. vulgaris* "in one small plot" (Jones, 1959, p. 92), and the Zinancantecos of Mexico who plant "several varieties of beans . . . in the same holes with the maize" (Vogt, 1970, p. 54).

CONCLUSIONS

Faced with the necessity of assuring his survival, the traditional agriculturist utilizes a wide array of both the interspecific and the intraspecific genetic resources at his disposal. Vavilov's (1951) Law of Homologous Variation suggests that color variation is a characteristic of all staple food crops. Cultivars of varying color often have distinct maturation periods and are widely used in traditional tropical agriculture as harvest-security mechanisms.

In a time of rapidly increasing population, recent attempts to expand world food output have focused on the diffusion of so-called "Green Revolution" technologies to the peasant farmers of the tropics. An integral element of these development packages is seeds or cuttings of an allegedly high-yielding variety of the staple food crop of the region. Although numerous test varieties are developed by the project plant breeders, we all too often offer a very limited selection (frequently only one variety) of improved seeds to the potential innovator rather than a collection of many varieties of varying colors and maturation periods. This approach is necessitated by the pressures for quick results. Often, however, the actual results are rejection by the intended beneficiaries of the effort. In addition to the fact that the so-called, high-yielding variety is not infrequently lower yielding than the native varieties (Instituto de Ciencia y Technología Agrícolas, 1980; Clawson and Hoy, 1979), the single-cultivar approach fails to adapt well to the plethora of microenvironments to which it is subjected (Miracle, 1966, p. 231). Most importantly, the small-scale innovator is left without his all-important survival mechanism. He is left with fewer means to overcome a germination failure or to provide a constant supply of food throughout the year. Although more expensive and time consuming to develop initially, greater long term acceptance of Green Revolution technologies is more likely to be achieved through offering the tropical farmer a selection of numerous improved varieties of his staple crop,

each differing in color and in maturation period. This goal can best be achieved through the continued analysis and preservation of the intraspecific genetic resources of tropical agriculture.

LITERATURE CITED

Anderson, E. 1952. Plants, Man and Life. Little, Brown, Boston, MA.

Barrau, J. 1958. Subsistence Agriculture in Melanesia. Bernice P. Bishop Mus. Bull. 219, Honolulu, HI.

———. 1961. Subsistence Agriculture in Polynesia and Micronesia. Bernice P. Bishop Mus. Bull. 223, Honolulu, HI.

Basile, D. G. 1974. Tillers of the Andes: Farmers and Farming in the Quito Basin. Univ. North Carolina Studies in Geography No. 8, Chapel Hill, NC.

Beadle, G. W. 1980. The ancestry of corn. Sci. Amer. 242: 112–119.

Berglund-Brücher, O., and H. Brücher. 1976. The South American wild bean (*Phaseolus aborigineus* Burk.) as ancestor of the common bean. Econ. Bot. 30: 257–272.

Brown, W. L. 1983. Genetic diversity and genetic vulnerability—an appraisal. Econ. Bot. 37: 4–12.

Brush, S. B. 1977. Mountain, Field, and Family. Univ. Pennsylvania Press, Philadelphia, PA.

———, H. J. Carney, and Z. Huamán. 1981. Dynamics of Andean potato agriculture. Econ. Bot. 35: 70–88.

Chang, J. H. 1977. Tropical agriculture: crop diversity and crop yields. Econ. Geogr. 53: 241–254.

Clawson, D. L., and D. R. Hoy. 1979. Nealtican, Mexico: a peasant community that rejected the 'Green Revolution'. Amer. J. Econ. Soc. 38: 371–387.

———, and R. E. Crist. 1982. Evolution of land-use patterns and agricultural systems. Mountain Res. Developm. 2: 265–272.

Codrington, R. H. 1969. The Melanesians. Oxford Univ. Press, London.

Colson, E. 1979. In good years and in bad: food strategies of self-reliant societies. J. Anthropol. Res. 35: 18–29.

Correll, D. S. 1962. The Potato and Its Wild Relatives. Texas Research Foundation, Remer, TX.

Coursey, D. G. 1967. Yams. Longman, London.

———. 1975. The origins and domestication of yams in Africa. *In* M. L. Arnott, ed, Gastronomy: The Anthropology of Food and Food Habits, p. 187–212. Mouton Press, The Hague.

Cox, C. B., I. N. Healey, and P. D. Moore. 1973. Biogeography: An Ecological and Evolutionary Approach. Wiley, New York, NY.

David, N. 1976. History of crops and peoples in North Cameroon to A.D. 1900. *In* J. R. Harlan, J. M. J. de Wet, and A. B. L. Stemler, ed, Origins of African Plant Domestication, p. 223–267. Mouton Press, The Hague.

de Wet, J. M. J., K. E. Prasada Rao, M. H. Mengesha, and D. E. Brink. 1983. Diversity in kodo millet, *Paspalum scrobiculatum*. Econ. Bot. 37: 159–163.

Ewell, P. T., and T. T. Poleman. 1979. Uxpanapa: Resettlement and agricultural development in the Mexican tropics. Cornell Agric. Econ. Staff Paper No. 79-10, Ithaca, NY.

Fischbeck, G. 1981. The Use of Genetic Resources in the Plant Kingdom. Union Internacionale pour la Protection des Obtentions Vegetales. Geneva.

Gentry, H. S. 1969. Origin of the common bean, *Phaseolus vulgaris*. Econ. Bot. 23: 55–69.

Harlan, J. R. 1975. Crops and Man. Amer. Soc. Agronomy, Madison, WI.

———, J. M. J. de Wet, and A. B. L. Stemler. 1976. Plant domestication and indigenous African agriculture. *In* J. R. Harlan, J. M. J. de Wet, and A. B. L. Stemler, ed, Origins of African Plant Domestication, p. 3–19. Mouton Press, The Hague.

———, and J. Pasquereau. 1969. Décrue agriculture in Mali. Econ. Bot. 23: 70–74.

Harris, D. R. 1976. Traditional systems of plant food production and the origins of agriculture in west Africa. *In* J. R. Harlan, J. M. J. de Wet, and A. B. L. Stemler, ed, Origins of African Plant Domestication, p. 311–356. Mouton Press, The Hague.

Hawkes, J. G. 1947. On the origin and meaning of South American Indian potato names. J. Linn. Soc., Bot. 53: 205–250.

Hickey, G. C. 1964. Village in Vietnam. Yale Univ. Press, New Haven, CT.

Hill, A. F. 1952. Economic Botany. 2nd ed. McGraw-Hill, New York.

Igbozurike, M. U. 1971. Ecological balance in tropical agriculture. Geogr. Rev. 61: 519–529.

Instituto de Ciencia y Technología Agrícolas. 1980. Fertilización de Variedades Criollas de Maíz Para Chimaltenango. Sector Público Agrícola, Bol. Téchnico No. 11. Guatemala City.

Johannessen, C. L. 1982. Domestication process of maize continues in Guatemala. Econ. Bot. 36: 84–99.

Jones, W. O. 1959. Manioc in Africa. Stanford Univ. Press, Stanford, CA.

Kaplan, L. 1981. What is the origin of the common bean? Econ. Bot. 35: 240–254.

Malinowski, B. 1965. Soil-Tilling and Agricultural Rites in the Trobriand Islands. Indiana Univ. Press, Bloomington, IN.

Massal, E., and J. Barrau. 1956. Food Plants of the South Sea Islands. South Pacific Commn. Tech. Pap. 94, Noumea.

Miracle, M. 1966. Maize in Tropical Africa. Univ. Wisconsin Press, Madison, WI.

———. 1967. Agriculture in the Congo Basin. Univ. Wisconsin Press, Madison, WI.

Moran, E. F. 1975. Food, development, and man in the tropics. *In* M. L. Arnott, ed, Gastronomy: The Anthropology of Food and Food Habits, p. 169–186. Mouton Press, The Hague.

National Academy of Sciences. 1972. Genetic Vulnerability of Major Crops. Natl. Acad. Sci., Washington, DC.

———. 1975. Underexploited Tropical Plants with Promising Economic Value. Natl. Acad. Sci., Washington, DC.

Parsons, J. J. 1968. Antioqueño Colonization in Western Colombia. Rev. ed. Univ. California Press, Berkeley, CA.

Patiño, V. M. 1963. Plantas Cultivadas y Animales Domésticos en América Equinoccial, tomo 2. Imprenta Departamental, Cali, Colombia.

Pérez-Arbelaez, E. 1956. Plantas Utiles de Colombia. Librería Colombiana-Camacho Roldán, Bogotá, Colombia.

Plucknett, D. L., N. J. H. Smith, J. T. Williams, and N. M. Anishetty. 1983. Crop germplasm conservation and developing countries. Science 220: 163–169.

Portal, M. 1970. El Maíz: Grano Sagrado de América. Ediciones Cultura Hispánica, Madrid, Spain.

Porteres, R. 1976. African cereals: eleusine, fonio, black fonio, teff, *Brachiaria, Paspalum, Pennisetum,* and African rice. *In* J. R. Harlan, J. M. J. de Wet, and A. B. L. Stemler, ed, Origins of African Plant Domestication, p. 409–452. Mouton Press, The Hague.

Purseglove, J. W. 1968. Tropical Crops: Dicotyledon. Wiley, New York, NY.

Rappaport, R. A. 1967. Pigs for the Ancestors. Yale Univ. Press, New Haven, CT.

Salaman, R. N. 1949. The History and Social Influence of the Potato. Cambridge Univ. Press, London.

Scudder, T. 1976. Social anthropology and the reconstruction of prehistoric land use systems in tropical Africa: a cautionary case study from Zambia. *In* J. R. Harlan, J. M. J. de Wet, and A. B. L. Stemler, ed, Origins of African Plant Domestication, p. 357–381. Mouton Press, The Hague.

Smartt, J. 1969. Evolution of American *Phaseolus* beans under domestication. *In* P. J. Ucko and G. W. Dimbleby, ed, The Domestication and Exploitation of Plants and Animals, p. 451–462. Duckworth, London.

Smole, W. J. 1976. The Yanoama Indians: A Cultural Geography. Univ. Texas Press, Austin, TX.

Spicer, E. 1967. The Impact of Technological Change. Wiley, New York, NY.

Stone, D. Z. 1975. The Boruca of Costa Rica. Kraus Reprint, Millwood, New York.

Ugent, D. 1968. The potato in Mexico: geography and primitive culture. Econ. Bot. 22: 108–123.

Vavilov, N. I. 1951. The Origin, Variation, Immunity and Breeding of Cultivated Plants. Trans. from the Russian by K. L. Chester. Ronald Press, New York, NY.

Vogt, E. Z. 1970. The Zinancantecos of Mexico. Holt, Rinehart and Winston, New York, NY.

Wassen, H. 1949. Contributions to Cuna ethnography: results of an expedition to Panama and Colombia in 1947. Ethnol. Stud. 16: 1–139.

Webster, C. C., and P. N. Wilson. 1966. Agriculture in the Tropics. Humanities Press, New York, NY.

Yen, D. E. 1974. The Sweet Potato and Oceania: An Essay in Ethnobotany. Bernice P. Bishop Museum Bull. 236, Honolulu, HI.