Farmer Maintenance of Sweetpotato Diversity in Asia: Dominant Cultivars and Implications for In Situ Conservation

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In situ conservation of plant genetic diversity has received growing attention in the last 30-40 years, primarily in relation to wild species. In Asia, the number of protected areas tripled between the 1960s and early 1990s (MacKinnon, 1995). In situ maintenance of crop genetic diversity, however, was not considered a viable conservation strategy by international organizations or leading specialists until recently (Williams, 1988; Frankel, 1970). The earlier assumption was that landraces were used only in traditional agricultural systems. Technological modernization then, especially the introduction of new cultivars, would inevitably lead to the loss of landraces in most cases. Since it would be both impracticable and immoral to preserve an entire system in its traditional state, it was argued, ex situ rather than in situ conservation was the only solution.

In fact, the cultivation of diversity has survived enormous historical changes in these supposed unchanging societies (Wolf, 1982). There is clear evidence that landraces continue to be cultivated under modern conditions and with modern technology (Brush, 1991, 1993). Nevertheless, some of these findings give rise to concern. Modern or selected commercial cultivars seem to have contributed in some cases to the decline of area, fragmentation into pockets or islands of production, and even the disappearance of indigenous cultivars altogether (Brush, 1993).

That is an important issue for sweetpotato (*Ipomoea batatas* (L.) Lam.) in Asia, the secondary center of diversity and the primary center of production and use of the crop. There is an urgent need to identify adequate national conservation strategies to ensure the continued availability of genetic diversity to farmers and plant breeders. In situ conservation could provide greater accessibility to diversity and, by spreading the costs of conservation, reduce the vulnerability of publicly funded ex situ genebanks. It could maintain diversity and habitat viability where continued crop evolution could take place provided a few commercial cultivars do not dominate and displace local crop genetic diversity.

To gauge the real potential of in situ conservation, it is necessary to fully understand cultivar maintenance practices of households under different socioeconomic and ecological conditions, and the dynamics of varietal dominance. Does dominance mean displacement? This paper draws conclusions for the future role of in situ maintenance in crop conservation strategies. It is based on case studies in three areas where varietal dominance is important.

Approach and Methods

To document and evaluate sweetpotato diversity in Asia and to understand how farmers maintain cultivars, CIP has supported germplasm collection and socioeconomic studies in the Philippines, Indonesia, and Vietnam since the early 1990s. Fieldwork methods have varied considerably. Some focused on collection and characterization with minimum documentation of

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indigenous knowledge. Others are extremely detailed, long-term documentation of local practices using participatory rural appraisal, ethnobotanical techniques, and monitoring of local germplasm collections.

The studies undertaken by UPWARD (Users' Perspective with Agricultural Research and Development), a CIP network, have identified four major sweetpotato production systems: (1) shifting cultivation in hillside and mountain areas, (2) home gardens, (3) upland rotations, and (4) lowland postrice systems (Prain, 1995). The last is the most commercialized production system in Southeast Asia and by volume the most important system in Vietnam, Indonesia, and the Philippines. The different systems influ-ence farmer maintenance of sweetpotato diversity.

Case Study 1. Shifting Cultivation in Mountain Environments

The case study on shifting cultivation in mountain environments is based on published and unpublished data collected in Wagawaga, Central Irian Jaya, Indonesia (Schneider and Yaku, 1996; Schneider et al., 1997; and Prain, Widiastuti, and Yaku, unpubl.). Wagawaga is in the northern part of the Baliem Valley, a large, flat agricultural area. The valley is surrounded by steeply rising mountain walls, which also support shifting agriculture. There are two main sweetpotato production systems. In one, *hipere wen*, sweetpotato is planted in individual mounds on high ridges surrounded by deep drainage ditches. The other, *yabu waganak*, is similar to *hipere wen* but without the drainage ditches. *Yabu waganak* is sometimes practiced in gardens near the compounds, particularly on hillsides.

As in most parts of highland Irian Jaya, steamed or baked sweetpotato is the staple food of Wagawaga families, accounting for as much as 90% of their diet (Heider, 1979). Production systems are designed to supply freshly harvested sweetpotato year-round. Households maintain several beds at different stages of development as well as mixtures of cultivars in each bed to ensure supplies. Mixtures are important. Local people compare the mixing of many sweetpotato cultivars in one garden bed with the need to *mix up* the clans for marriage to ensure the continuity of the tribe. Short duration cultivars are important components of the mixtures. The number of cultivars maintained per bed ranged from 7 to 20, with an average of 12. Women who maintain multiple sweetpotato beds do not plant the same set in each bed, but the most important cultivars are likely to be common in all beds.

Wagawaga was designated as an in situ site in 1994. A preliminary study on the genetic diversity (Yuliantiningsih, 1995) identified 47 cultivars in the 30 beds of the in situ study garden. A follow-up documentation of 30 beds in 1998 also documented 47 cultivars, but only 27 of these were the same as the cultivars planted in 1994 (Table 1). The distribution of the different sets of cultivars in 1994 and in 1998 are quite similar, although the beds documented in 1998 were not exactly the same as those in the 1994 study since beds are periodically remade within the same garden area. We can better understand the cultivar distribution by considering two key characteristics of farmers' cultivar management: the number of plants of a cultivar and the frequency with which the cultivar is planted in different beds (Figures 1 and 2). The planting density of cultivars was calculated differently in 1994 and 1998. In 1994, the total number of plants in the garden was counted and the percentage of the total calculated for each cultivar. In 1998, each bed was mapped and the percentage each cultivar occupied in the bed was calculated.

Helaleke asli was the most widely planted cultivar in both 1994 and in 1998, with 34.9% of bed area in 1994 and 42% in 1998 (Cluster 1, Figures 1 and 2). This cultivar is the most important human food in Wagawaga and, in particular, is the

Table 1. Cultivars planted in Wagawaga, Irian Jaya in 1994 and 1998.

Cultivars present 1994	Cultivars present 1998	Cultivars present 1994	Cultivars present 1998	Cultivars 1994	Cultivars present 1998
Helaleke asli	Helaleke asli	Ponai	-	-	Kafiar
Hupuk	Hupuk	Tuke asli	-	-	Suweal baru
Hopoye	Hopoye	Puluk	-	-	Leget pilodok
Musan	Musan	Mikmak	Mikmak	-	Kakum eka
Namukera	Namukera	Musaneken baru	-	-	Musan baru
Musaneken	Musaneken	Saporeken	Saporeken	-	Kentang
Abukul	Abukul	Salisike	Salisike	-	Wiyayuken
Alukulek	Arukulek	Suweal	Suweal	-	Tinta hitam
Kilaake	Kilaake	Sabolok	-	-	Juaiken baru
Helakeke baru	Helakeke baru	Tabogole	Tabogole	-	Wopem
Inin	-	Tinta	Tinta	-	Tinta putih
Juaiken	Juaiken	Tamue	Tamue	-	Kulameke
Duak	-	Welelom Sumunah	Welelom Sumunah	-	Tinta merah
Ebe asli	-	Welelum Baru	Welelum Baru	-	Yakik
Fibisak	Hibisak	Wenaboge Molah	-	-	Hoboak
Ogopem	-	Wenaboge	Wenaboge	-	Lisuge
Nobokum	Nobokum	Wereneh	Wereneh	-	Baruke
Hulok	Hulok	Helaleke Hulek	-	-	Aluage
Hupaleke	-	Helaleke Walagin	-		
Kilu	-	Yibilaken	-		
Hupuk Sumunah	-	Wosilolo	Wosilolo		
Pilka	Pilka	Kumbuk Aidek	-		
Pogoreken	-	Mayugwe	-		
Pulugia	-		Wortel		

appropriate food for women to present to men. The second most widely planted cultivar, in area and in number of beds where it was grown, was Musan. It occupied 16% of bed area in 1994 (Figure 1) and 24% in 1998 (Figure 2). This cultivar produces large roots and is an important source of pig feed in the area. According to women (who plant and tend the beds), the proportion of beds dedicated to particular cultivars varies, depending on the proportion of people and pigs in households and compounds.

The second clustering (Cluster 2, Figures 1 and 2) includes cultivars planted in more than 10 beds and which occupy more than 1% of bed area. These clusters comprise cultivars that are also important, but for different reasons. One is connected with the use of sweetpotato for baby food, such as cultivars Arukulek, Welelom, and Welelum Baru. The rapid diffusion of the new cultivar Wortel between 1994 and 1998 seems to be due to its orange color and less floury texture, preferred characteristics for baby food. Some, such as Hupuk are ancestral cultivars. They must be planted, often before other cultivars and by the fertility chief, for the sake of the ancestors and to ensure a bountiful harvest. Many of these cultivars are valued as adult food and are also fed to pigs, especially the smaller roots.

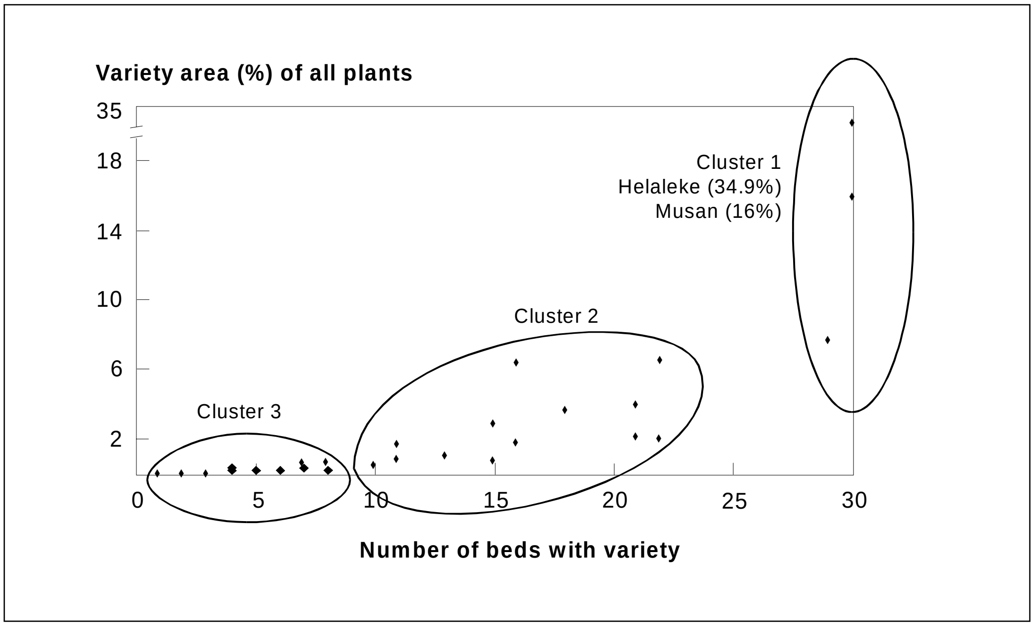

Figure 1. Distribution of 47 sweetpotato cultivars in 30 beds, Wagawaga, Irian Jaya, Indonesia, 1994.

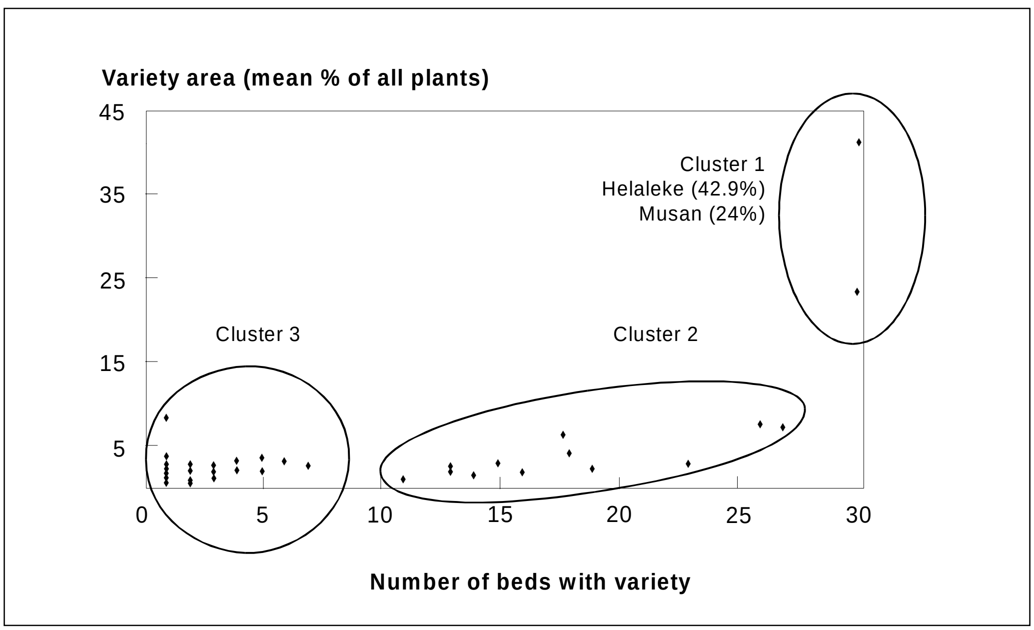

Figure 2. Distribution of 47 sweetpotato varieties in 30 beds, Wagawaga, Irian Jaya, Indonesia, 1998.

Cluster 3 involves cultivars that appear *residual*. In 1994, 30 of the 47 cultivars were grown in fewer than 10 beds and accounted for only 4% of area. In 1998, 33 cultivars were grown in fewer than 10 beds and accounted for 6% of area. Women say they do not *forget* to plant any of the cultivars, even these with such tiny representation. However, they may not replant some cultivars if they do not find cuttings, which is especially possible with this last cluster. These cultivars account for most of the variation between 1994 and 1998 as they slip in and out of the system. Of the 20 cultivars that disappeared, almost all covered less than 0.5% of beds and were planted in fewer than 5 beds.

A similar situation applies to the newly introduced cultivars in 1998. Almost all were found in fewer than 5 of the 30 beds, with very small area planted. Exceptions are Tinta (in 18 beds in 1998) and Wortel (14 beds). Tinta is grown as pig feed. Wortel is grown as baby food and for sale to non-Irianese consumers who like its yellow flesh. Both cultivars are new (*baru*), meaning they have recently been introduced or identified as novel types, probably having emerged as seedlings.

Case Study 2. Upland Semicommercial Rotations

The upland rotations case study involves a semicommercial system practiced in Maambong Province on Mindanao, the southernmost of the larger Philippine islands (Prain and Piniero, 1999). It is one of the wettest areas of the country with well-distributed rainfall allowing crops to be planted throughout the year. That favors sweetpotato conservation, because vegetative planting material is readily available for replanting. Maambong is situated in the relatively flat, northern part of a generally undulating grassland plateau, crosscut with deep river valleys.

Farmers practice adapted plow agriculture and rotations on the plateau and in the hills, especially for maize, root crops, and, more recently, vegetables. Another common production system is the home garden, which normally supports a large amount of biodiversity. Sweetpotato is a supplementary staple in both systems. There has been a steady increase in sweetpotato genetic diversity with the influx of cultivars brought by migrants from the northern coast and from nearby smaller islands. However, the growth in diversity may have peaked around the early 1980s. That was around the time a multinational pineapple plantation became an increasingly important employer in the area; this increased opportunities for vegetable production.

Through an agreement with an informal group of women in Maambong, a *conservation garden* was established. The garden, initially consisting of 24 beds, was modeled after household gardens. Following initial experimentation, however, the women adopted a rotation system with peanut for replanting their root crop collections. Each woman cultivated her own plot and initially planted cultivars from her own fields and garden, leading to considerable duplication of cultivars across the plots.

There was a sharp rise in sweetpotato diversity in the second planting, from 11 to 19 cultivars, with one lost (Table 2). That can be explained by several factors, the most important of which is the influence of the project itself. The considerable interest and enthusiasm among the women in diversity maintenance resulted in their scouring the locality for additional cultivars. However, five of the added cultivars had already disappeared from the garden by the third planting; all had disappeared by the fifth planting. It was felt that the project had heightened the normal practice of evaluating any new cultivar for which planting material is available.

That impression was supported by the similar pattern that characterized subsequent plantings, with a few rare local or exotic cultivars added only to be abandoned later. A cluster of preferred cultivars present from the beginning of the garden (Klarin, Five Fingers, Igorot Pula, Igorot Puti, Amerikano, Kamada, and Tapol) were consistently planted by most women and gradually became the main cultivars (Table 2). Furthermore, in later plantings there was a tendency to reduce the numbers of plants of other cultivars in favor of the preferred cultivars. That was particularly true of Klarin and Five Fingers, which are popular

Table 2. Sweetpotato cultivars planted in the Maambong genebank over five seasons.

First planting	Second planting	Third planting	Fourth planting	Fifth planting
Klarin	Klarin	Klarin	Klarin	Klarin
5-fingers	5-fingers	5-fingers	5-fingers	5-fingers
Igorot Pula	Igorot Pula	Igorot Pula	Igorot Pula	Igorot Pula
Tapol	Tapol	Tapol	Tapol	Tapol
Amerikano	Amerikano	Amerikano	Amerikano	Amerikano
Bilaka	Bilaka	Bilaka	Bilaka	
Igorot Puti	Igorot Puti	Igorot Puti	Igorot Puti	Igorot Puti
Kamada	Kamada	Kamada	Kamada	Kamada
Valencia	Valencia	Valencia	*Valencia*	
Kinampay	*Kinampay*	**Kinampay**	Kinampay	*Kinampay*
Kaligatos	Kaligatos	Kaligatos	*Kaligatos*	Kaligatos
	Tinangkong	Tinangkong	Tinangkong	*Tinangkong*
	Kapitlok	Kapitlok	*Kaligatos*	
	Kabohol	Kabohol	*Kabohol*	
	Sil-ipon	Sil-ipon	*Sil-ipon*	
	Magtuko	*Magtuko*		
	Maranding	*Maranding*		
	Senorita	*Senorita*		
	Imelda	*Imelda*		
	Kitam-is	*Kitam-is*		
		Lila	*Lila*	
		Initlog	*Intilog*	
			PNGL	PNGL
			Kawakwak	Kawakwak
			P16	P16
			NPSP	PNSP
			Salayaw	*Salayaw*
			UPLSP	UPLSP
			Kabato	*Kabato*
			Turay	*Turay*
Total 11	19	17	17	13
Additions	+ 9	+ 3	+ 8	+ 1
Losses	- 1	- 5	- 8	- 5

Note: Cultivars in bold are additions.
Cultivars in italics are losses.

in the fresh market. Characteristics of the preferred cultivars are given in Table 3. The wide genetic diversity suggests close relation between diversity of use and genetic diversity.

Case Study 3. Lowland Postrice Systems

The lowland postrice sweetpotato production system case study (Anganon et al., 1998; Data et al., 1997) is based on the key commercial sweetpotato producing

Table 3. Morphological characterization[a] of continuously planted, dominant cultivars in the Maambong, Philippines, genebank, 1998.

Cultivar	Plant type	Vine color	Leaf vein	Leaf shape	Immature leaf col.	Petiole pigment	Root shape	Skin color	Flesh color	Extracts of farmers' characterizations
Klarin	7	1	2	5332	32	1	8	830	100	Grows easily; roots dry, sweet; tops for vegetable, forage; salable
Five Fingers	7	3	5	6755	72	3	3	634	442	Early maturing; leaves for vegetable; roots sweet, watery; salable
Amerikano	7	7	8	3131	95	9	8	126	543	Profuse vines; few big roots; roots sweet, powdery
Igorot Puti	9	3	3	5332	62	3	8	230	200	Profuse foliage, good for weed control, forage; roots sweet, dry
Igorot Pula	7	3	5	5334	92	8	3	230	100	Roots dry, sweet; leaves for vegetable; salable
Tapol	5	7	8	3151	95	9	2	930	196	Easy to maintain; Roots unsweet, watery; leaves for vegetable; good market for this color; small area
Kamada	5	1	2	5332	23	3	3	520	100	Early maturing; easily harvested; root sweet, watery; tops suitable for forage

Key: Plant type = 1 erect, 9 extremely spreading. Vine color = 1 green, 9 totally dark purple. Leaf vein color = 1 yellow, 2 green, 3 purple spots main rib, 4 purple spots several veins, 5 main rib partially purple, 6 main rib mostly purple, 7 all veins partially purple, 8 all veins mostly purple, 9 lower surface and veins totally purple. Leaf shape (combination of 4 numbers): 1st Outline = 1 rounded, 7 almost divided; 2nd Type of lobe = 1 none, 9 very deep; 3rd Lobe number; 4th Shape of central lobe = 0 absent, 9 linear. Immature and mature leaf color (combination of 2 numbers) = 1 yellow-green, 9 totally purple. Petiole pigment = 1 green, 2 green with purple near stem, 3 green with purple near leaf, 4 green with purple both ends, 5 green with purple spots throughout, 6 green with purple stripes, 7 purple with green near leaf, 8 some petioles purple, some green, 9 totally/mostly purple. Root shape = 1 round, 9 long, irregular or curved. Skin color (combination of 3 numbers): main = 1 white, 9 dark purple; intensity = 1 pale, 3 dark; secondary = 0 absent, 9 dark purple. Flesh color (combination of 3 numbers): main = 1 white, 9 strongly pigmented; second color = 0 absent, 9 dark purple; distribution of color = 0 absent, 9 covering all.

region in Central Luzon, the Philippines. Located about 50 km north of Manila, it is the main supplier for the urban fresh root market. Sweetpotato is commercially grown in ricefields during the dry months from December to April, with peak harvest in March. Central Luzon's six provinces had a sweetpotato production area of approximately 9,000 ha in the early 1990s. Recently, the area has expanded to 10,000 ha through increased demand for sweetpotato as a raw material for large-scale starch processing. Moreover, destructive flows of volcanic debris resulting from the eruption of Mount Pinatubo in 1991 forced the shift from rice and sugarcane to sweetpotato.

A total of 25 sweetpotato cultivars have been grown in the region since the early 20th century, according to farmers. Only four are now widely grown and a single cultivar Superbureau covers at least 80% of the total production area. High root yield, marketability, and early maturity are the most important traits considered by farmers. Historically, farmers grew a mix of cultivars for both general and specialized uses. For instance, two popular cultivars, Bureau and Taiwan, were preferred for the high quality of their boiled roots. Girayan and Lampangog were grown because they commanded high prices for their use in traditional dishes. Finally, the establishment of starch factories created a demand for Superbureau as a processing cultivar.

Availability of planting materials has also been a major determinant of cultivar. Most farmers maintain their own mini-seedplots of preferred cultivars. With the high demand for planting materials at the start of a cropping season, some enterprising farmers have offered specialized seed production and marketing services. The cultivars propagated by these commercial suppliers determine the varietal combinations for the next season. For instance, Tarlac farmers, faced with the acute shortage of their preferred Bureau, resorted to planting Superbureau, the only material available from seed suppliers from the neighboring province. The seed suppliers have in turn been responding to agroecological and socioeconomic changes in the region. Bureau was being severely affected by feathery mottle virus (SPFMV) and possibly other viruses in the early 1990s and seed growers began looking for an alternative cultivar. Superbureau had many of the characteristics of Bureau, but was more resistant to SPFMV and more appropriate for the developing processing industry. In 1998, Superbureau itself began exhibiting a similar susceptibility to the virus complex, prompting farmers to seek newer, more tolerant cultivars. Meanwhile, with increasing attention to the processing market, cultivars high in dry matter became important.

Despite the relative uniformity of the postrice system in Central Luzon, agroecological variation affecting cultivar choice still exists. Variation may be stable and long-term such as in soils, topography, drainage, etc. For example, in some areas Superbureau performs very poorly. Or variation may be produced through natural disasters such as the accumulating volcanic debris in agricultural land after the Mount Pinatubo eruption. For instance, there has been greater preference for Ube over Binicol in some affected areas.

Patterns of Diversity: Maintenance, Dominant Cultivars, and In Situ Conservation

In all three case studies, one or two cultivars are preferred. They are planted by most farmers and over much larger areas than other cultivars. That reflects the fact that the dominant local concerns will be reflected in the one or two cultivars that best address those concerns. Even when dominant concerns are the same, such as cultivars for home consumption or for sale in the market, they can result in different dominant cultivars. That is because the agroecological conditions themselves vary and different cultivars adapt in different ways such as between provinces in Central Luzon or between Irian Jaya's hill-dwelling and valley-bottom farmers. Similarly, in Mindanao comparative studies of neighboring communities revealed that different, but isomorphic, genotypes essentially fulfil the same function (Prain and Piniero, 1999). Given the variability of the environment that exists in the uplands, especially in the mountains, we can expect to find considerable genetic diversity, even when cultural preferences are similar.

When we observe cultivar maintenance along the dimensions of frequency of planting in different beds and the more common measure of plant density per bed, the regular and often substantial occurrence of other cultivars indicates other important societal concerns. In Maambong, in addition to the two dominant cultivars grown primarily for the fresh market, other cultivars are maintained for early maturity, vegetable use, pig feed, etc. In Wagawaga, while Helaleke asli and Musan are the main sources of food and feed, respectively, several cultivars are also maintained for infant food or for sale. The most striking example of what we can call *cultural saliency*, however, is the role of particular cultivars in rituals of first planting and consecration of land.

In both Wagawaga and Maambong, the dynamism of local maintenance appears to occur primarily among cultivars that are planted in a few beds with few plants per bed. Ritual cultivars also have few plants per bed, but the many women who plant them do not let them disappear. The old cultivars are planted first, not only to comply with custom but because they are said to need more fertilization than exotic cultivars. The extreme case is Inin, which is planted in a pile of ash from burnt branches of cleared garden to ensure production. This careful management contrasts with the treatment of cultivars in few beds and small areas. These residual or experimental cultivars, which might certainly include the products of fortuitous seed germination, usually enter and exit individual collections quite rapidly. Occasionally, a cultivar like Wotel or Tinta will be taken up by increasing numbers of farmers.

The Central Luzon case indicates that in the past diversity of use stimulated diversity of cultivar. More recently there has been a shift from spatial to temporal diversity, a process shared with other highly commercial areas (Prain and Fano, 1991). The one or two commercial cultivars covering a wide area are quite rapidly replaced as their productivity declines due to disease, they are outperformed by new cultivars, or market demand changes.

Conclusions

These findings have implications for in situ conservation strategies. A more comprehensive analysis of dominance suggests that evolution toward modern sweetpotato agriculture dominated by a single cultivar is not inevitable. Even if sweetpotato were to become a more commercial crop in Wagawaga, the maintenance practices are resilient enough to incorporate one or two commercially dominant cultivars without overall decline in variability. Maambong also gives reason for optimism. There the same kind of cultural salience characterizes several cultivars besides those dominant in plant density. Moreover, in the upland, particularly the hillside environments of these regions, there is isomorphic variability. That is, genetically diverse cultivars with similar cultural salience are found at different sites in a region. One could therefore envision a network approach to in situ conservation. Sets of culturally salient and genetically highly diverse cultivars could be maintained in selected sites within a region. The contribution of the national genetic resources conservation system toward this type of farmer-led conservation should focus on five things.

1. Public recognition of the value of local germplasm and local knowledge of it.
2. Public recognition of the participation of site representatives in a national conservation effort.

3. Simple reward system involving agricultural seeds and low-input technologies.
4. Facilitating access to exotic germplasm from other sites and from breeding programs.
5. Supporting continuing diversification of use and the cultural salience of different cultivars.

Although the kinds of lowlands represented by Central Luzon are unlikely to become repositories of genetic diversity, in situ conservation strategies at least should attempt to increase local diversity through diversifying uses (Amihan-Vega and Bacusmo, 1999). That could help to avoid the serious consequences that virus disease is now having on the mono-cultivar crop in Central Luzon.

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