Farmer Practices and Sweetpotato Diversity in Highland New Guinea

Jürg Schneider *

Introduction

Up to the present, the societies of the New Guinea highlands have depended to a great extent on sweet potato as a staple food. The importance and diversified use of sweetpotato are reflected in varietal diversity, and there is a tremendous amount of it in the main regions of sweetpotato cultivation.

The number of local cultivars collected or documented during plant collections may serve as a first indicator of varietal diversity; local cultivar, also known as a landrace, is a cultivar distinguished, selected and named locally. In Papua New Guinea, about 1,000 local cultivars have been collected and are maintained on agricultural research stations, and this is only part of the existing diversity (Bourke 1982). In two collection trips in the highlands of Irian Jaya, I have participated in the collection and documentation of about 450 cultivars (Schneider et al. 1993). In the Baliem Valley in the Central Highlands (Jayawijaya regency) with a surface area of less than 1,000 km^2, at least 200 local cultivars occur, and about the same number of cultivars is found in the mountainous area to the west of the great valley. An exploration in the division of Paniai (western highlands) collected 139 cultivars (Matanubun et al. 1991).

A big inventory of local names does not imply that the respective cultivars have a broad genetic base. In the case of Irian Jaya, which is a secondary center of diversity, the genetic base of sweetpotato is most likely smaller than in South America. This has been demonstrated by Yen (1974) after careful study of morphological characters of sweetpotato varieties from all its centers of cultivation. The maximum range of variation was found in South American varieties. In other centers of cultivation in Asia and the Pacific, variation was less but varied again between these centers. For Yen (1963), this was genetic evidence for successive introductions into these areas. The patterns of differences between the introduced sets persisted because they had - at least at the time of his collections in the 1950s - not been obliterated through historic exchanges nor through recent introductions.

The introduction of sweetpotato is assumed to have caused a substantial transformation of highland agriculture because it allowed the expansion of cultivation into higher altitudes and the creation of different agro-ecologies. The new crop was adopted into already highly developed agricultural systems often based on taro. The present dominance of sweetpotato in most parts of the highlands has been seen in two factors where it outcompetes particularly taro: first, its higher adaptability to environmental risks such as drought and low temperature, and second its higher productivity combined with its great suitability as a pig

* Anthropologist, currently working for the Institute of Ethnology, University of Berne, Switzerland. This paper was presented at the Euroseas Conference, Leiden, June 1995. The author thanks his colleagues Il Gin Mok, C.A Widyastuti, Ahmad Dimyati, Hubertus Matanubun, Gordon Prain and La Achmady for their contributions to the research from which this paper draws.

feed both in cooked and uncooked form (whereas uncooked taro is not eaten by pigs). The sweetpotato enabled highland societies to expand settlement into higher altitudes (much above 2000 m), to shift their subsistence base from hunting more towards horticulture, and to raise more pigs.

The history and impact of the introduction of sweetpotato into the diverse agricultural systems of New Guinea has been subject of an extensive scholarly debate, yet it remains something of an unsolved problem. Botanical and genetic studies have shown that sweetpotato (Ipomoea batatas) is of American origin, with a probable center of origin in western South America (Yen 1974). The view most commonly held since Yen's pioneering study is that Ipomoea diffused prehistorically to the Western Pacific, but arrived in New Guinea only after the Iberian exploration of the Indonesian archipelago (Yen 1974). It then would have arrived in the interior considerably later. Golson (1990), for example, estimates that sweetpotato arrived only 250 bp in the Wahgi Valley; and Sorenson (1972) has the Fore in the Eastern highlands cultivate it for just over 100 years. The view of a fast and radical change of highland agriculture after the introduction of sweetpotato was basic to the debate on the "Ipomoean revolution" of the 1960s and 70s (Watson 1967, 1977).

Recently, the hypothesis of a post-magellanic introduction has been scrutinized based on examination of the generic terms of sweetpotato used in 450 languages in New Guinea and their patterns of distribution (Scaglion et al. 1994). The authors posit that at least two sets of names encountered all over eastern and central New Guinea provide evidence for other possible routes of introduction from Polynesia, thus from an easterly direction, and conclude: "It is quite likely that there were multiple introductions of the sweet potato into New Guinea." So far, archeological or other evidence that would support this hypothesis is lacking. If it could be provided, the varietal evolution of sweetpotato in the highlands would have been considerably longer than the 100-400 years assumed so far.

The concern of the present paper is less with diffusion than with the management of sweetpotato varieties by highland peoples, an aspect which has received only cursory attention so far. Referring to scattered remarks in the literature and to data gathered during short fieldtrips to Irian Jaya between 1992 and 1994, I would like to argue that the human factor in variety development should be reconsidered. The following questions seem to me the most pertinent:

- How is the relationship of names (cultivar inventory) to actual morphological diversity conceptualized?
- If we can assume a restricted number of introductions, how did local cultivar inventories develop and diversify towards present levels?
- Do people recognize the sources of new varieties, or is it a process largely hidden from the consciousness of farmers?
- What are the human and natural factors which contribute to - or minimize - the evolution of new genotypes?

Local inventories: "playful naming" or representation of morphological diversity?

Any study of the ethnobotany of sweetpotato has to start with the identification of local varieties by the people who cultivate them. Most studies with a general outlook provide us with a simple number of total varieties identified for a crop species. Sometimes, a more detailed cultivar inventory is provided (Sillitoe 1983). The numbers most often indicated for specific areas in the literature range between 20 and 80.

It was his surprise about the high number of sweetpotato varieties in the Baliem Valley that led Heider (1969) to try to explain what he called "the proliferation of names". He thought it unlikely "that any one person could manage with any consistency a set of 30 or 50 or more complementary categories in a realm like sweet potatoes."
He suggested some possible reasons for the long cultivar inventory, and I would like to mention three of them: dialects, functional differences, and cultural elaboration.

The Dani language consists of three major dialects, and many more minor variations: each community may thus have a different set of names for the same types of varieties. To a certain extent, this is the case. However, our data from collections in the valley show that there is also considerable overlap of names across the dialect areas, and these names seem to correspond to the same morphological types. This is not surprising given the considerable time during which sweetpotato has been cultivated and probably also exchanged between communities.

Varieties are named because of differences in taste and ecological adaptation. Gastronomic qualities are indeed the most easily elicited knowledge associated with sweetpotato varieties. Heider found that his informants grouped varieties into particularly good-tasting ones, and ones only fit for pigs. There was also a big group of varieties that held a "gastronomic middle-ground" with no salient characteristics. As far as ecological adaptation is concerned, Heider (1969) could not obtain evidence for what he called "insurance hypothesis". The expectation that farmers would use their knowledge of distinctive adaptations to a number of micro-environments or natural stress factors, such as flooding, by planting "each bed with a selection of varieties to insure a crop even should unexpected conditions destroy some vines."

As a matter of fact, the Dani do invariably plant their sweetpotato beds with a mixture of 10 to 40 varieties, and they do this with a knowledge of each variety they have planted. Presently, we have still very limited information as to whether these mixtures are determined more by consumption needs, or by adaptation to micro-environments. There are in fact two major agro-ecologies to be found in the Baliem Valley: an alluvial, rather wet valley bottom, and the drier slope areas surrounding the valley. Farmers distinguish varieties with respect to their broad adaptation to these two zones. Thus, they would not plant a certain number of hill varieties in the valley bottom, and vice versa. Yet, the choice of varieties within the beds is to our knowledge not related to explicit ecological considerations, though it is evident that it not only serves diverse consumption needs, but may also have ecological functions, such as reducing susceptibility to diseases.

If other explanations for the great sweetpotato "lexicon" in this area fail, Heider finally suggests, one might consider that sweetpotatoes represent an area of cultural elaboration, an opportunity for playful naming so that for one single variety, several names are produced. This seems to me the least convincing of Heider's suggestions. In our own research, we found very few examples of varieties with duplicate names, and none with more than one alternative. If "playful naming" would in fact be a general trend, this might in the end be obstructing identification of varieties, and the very logic of relating names to distinctively perceived varieties. After morphological observation of the material we collected in 1993, we would argue for a representation of plant variation in the variety inventory. The characterization work conducted in Indonesia has shown so far that the large majority of names refer to distinctive varieties. Local perception as represented by a distinct variety name seems to closely correspond to differences in taxonomic characters developed by plant geneticists, who have developed detailed lists of descriptors, or taxonomic characters on the species level (see Huaman 1991 for sweet potato), which allow us to characterize and distinguish varieties under controlled growing conditions. In the case of sweetpotato, leaf

shape and pigmentation, as well as some characters of the vine, but not the root, are basic descriptors.

Heider's statement that ".. 70 words for sweet potato seems a bit much" gives little credit to local agriculturists. If the Danis could have read him, would it not be their turn to wonder? As anthropologists, we have a professional inclination to look for symbolic explanations, but this I think is misleading us in this case.

Cultivation practices and sources of genetic variation

In his pioneering work on sweetpotato variation in Oceania and Southeast Asia, Douglas Yen (1963) was the first to take a closer view at how sweetpotato is propagated and selected in New Guinea highland agriculture. His remarks will bring us back on the track of human-environment interaction: "A consistent characteristic of sweet-potato cultivation is propagation by vegetative means using vine-cuttings commonly, and tubers rarely: in no area visited was the natural seed purposely used. The incidence of seed, however, is by no means rare."

In all highland agricultural systems that have been described so far, plants are reproduced vegetatively (through replanting of cuttings). As a consequence of this clonal propagation, the genetic identity of a cultivar or genotype is preserved. In other words, the system of propagation common all over the highlands does not support genetic recombination. Yet existing varietal diversity does strongly indicate the existence of such a process. What are then the conditions that actually favor recombination?

There are two basic genetic processes other than introduction through which new genotypes can emerge and, if selected, a cultivar inventory can build up: somatic mutation and sexual reproduction which in turn presupposes flowering and seed setting. Yen (1963, 1974) believes that most of the differentiation was caused by the second process, and this was greatly supported by the common occurrence of seed in most agricultural systems of New Guinea where sweetpotato had become important.

However, seed is not necessarily valued by the farmers as the source of new cultivars. In Peru, local farmers told Yen that they were reluctant to use seed because resultant tubers were of poorer type and lower yield than established ones. Indeed, the great advantage of clonal propagation is its relative stability with which even a mixture can be planted and maintained over successive generations.

Sexual propagation through seed, though incidental, is favored by continuous cultivation. The sweet potato plants are left in the garden during the whole period of staggered harvesting and even after harvesting has finished. There are thus many old gardens where plants can reach the stage of natural reproduction. Moreover, flowering and seed-setting often occur in beds planted with variety mixtures. Thus, hybridization of existing varieties is more likely, and so is the chance that seedlings in old gardens are new genotypes. Farmers do not exploit such seed systematically to get new cultivars. Yen thinks that farmers just don't know about sexual reproduction of sweetpotato (1974). However, he cannot cite much evidence for this contention. Certainly, sexual reproduction involves a plant metamorphosis (from seed to seedling) which may not be adequately reflected in local knowledge.

Indigenous knowledge of "volunteer seedlings"

There are a number of reports confirming that farmers are aware of the potential diversity of volunteer seedlings, i.e. seedlings spontaneously growing in gardens or fallowed land. These new and often hybridized varieties are observed and may be adopted as new varieties.

Stimulated by Yen's (1960) observations, Bulmer (1965) provided a short report on observation and selection of volunteer seedlings of sweetpotato among the Enga. A group of women and boys from Kyaka Enga told him that the rokeyaka bird was responsible for the seedlings through defecating seed which subsequently germinated. When they discovered seedlings they waited to see how these developed. If they produced a good crop they took slips and propagated them: if they were no good they were weeded out. During subsequent inquiries among the Karam, he found the same type of beliefs, although this people seemed to be less attentive towards the seedlings than the Enga group.

In our research, we also found the reference to birds in a number of Western Dani variety names. The name *tuwenekara* for instance was translated into Indonesian as *burung hinggap*, meaning a bird alighted. This evokes the concept of birds defecating seeds in gardens just mentioned.

How can we interpret this concept of the birds propagating seed of sweet potato? Bulmer found that the idea may be linked to both observation of natural phenomena by the people and cosmological concepts. A number of bird species are known to frequent sweetpotato gardens, and it is these species which are held responsible for the propagation. Bulmer (1965) identifies the following, in addition to the rokeyaka or Willie Wagtail (Rhipidura leucophrys): the Midget Flower-pecker (Dicaeum geelvinkianum) and the Swamp Quail (Synoicus ypsilophorus). As a matter of fact, sweetpotato seeds have a very hard outer coat. It may well be that partial digestion erodes the coat and may enhance chances for germination.

In some cases, the origin of varieties is associated with other concepts, such as the corpse of a women from which the first plant of a certain variety would have grown (Bulmer 1965). I have recorded a similar story in the Ngalum community of Abmisibil in the Star Mountains. These cases represent a common topos, and are embedded in the mythological view of the origin of domesticated plant varieties. It is, however, interesting, that they appear side by side with more pragmatic concepts of variety evolution for which we find evidence both in variety names and in the practice of evaluating seedlings.

That varieties evolve locally in the process of cultivation is reflected by occurrence of names indicating the time when a variety was encountered during garden work (e.g. *linggoara*, "found at noon"), and by the subdivision of variety names into subvarieties which are further qualified, e.g. as "new" and the "old" form of cultivar *x* (Schneider et al. 1993).

A seedling may volunteer, but what does it require for it to become a variety? It is observation and selection by farmers which eventually may establish an interesting individual as a new member of the cultivar inventory.

In Okelwel, another Ngalum community in the Star mountains, I could observe several volunteer seedlings - locally called *bilfuklon* - in a recently burnt and planted clearing. It was a garden plot that had been cultivated twice before, and fallowed for several years between. The farmers confirmed that it was not unusual to find these volunteer seedlings in new clearings. The characters of these plants were said to be very variable; root color for example could vary within the whole spectrum, from white to yellow to red. The fate of the seedling will be decided at harvest. The gardener who digs out the roots and finds them acceptable will give the variety a name. Others might then propagate it from vine cuttings.

Unfortunately, I did not ask whether *bilfuklon* was locally believed to be related to birds. The example here is from a new clearing where seed from the previous garden cycle

has survived. It seems plausible that the clearing and burning creates favorable conditions to the germination of sweetpotato seed.

The observation of the volunteer seedling is the decisive stage. Its adoption as a variety hinges on its usefulness, on its evaluation by a cultivator of a certain garden. It represents the interface between the genetic and the cultural process. Not surprisingly, this process has not been documented yet, but what I argue here is that we should take it more seriously and see it as a more systematic and more important process than it would appear from the literature. My point in general is that here we have an agricultural system with garden practices favoring variety evolution, and a crop - sweetpotato - which is vegetatively propagated. Both factors are important:

- Throughout the highlands, variety mixtures are absolutely basic characteristics of gardens. Known diversity is valued by the people; as planting material, it is constantly flowing from old to young gardens, and it is being exchanged among and within groups of gardeners. The diversity is cultivated in mixtures down to the level of individual garden plots, i.e. on the level where it really matters genetically. The chances for hybridization are thus greatly increased.
- This creates something of a paradox because hybridization is not desired by the cultivators. Instead, they want to retain distinct characteristics, or the components of their mixtures. This is an easy task for sweetpotato as long as it is vegetatively propagated. Seedlings are just a by-product with an unknown value. The cultivator can retain the characteristics of a desirable individual by cloning it.
- The plant organ with the highest functional value, the root, is hidden and cannot be used for immediate recognition or evaluation of useful characteristics. The gardeners thus have to develop a sharp perception for other distinctive features. This exploitation of difference above the ground may or may not result in important differences in taste, sweetness, etc. The cultivators tend to adopt what Boster (1985) called "selection for perceptual difference" (SPD). In other words, perception comes prior to selection.

His study on a manioc-growing community in the Amazon indicates that the number of basic uses is much smaller than the number of varieties: Sixty odd varieties correspond to only two basic uses: manioc for beer and manioc as a staple food. The beer-making varieties grow more rapidly, produce larger roots, have more fiber, and rot more rapidly after harvest. The other group is boiled for eating.

Yet, the actual number of varieties is much larger, each cultivar being mainly distinguished on the basis of leaf morphology and stem. These are most often gradual differences, not marked ones, such that the outsider even has difficulties to see them. Why are so many maintained? A (traditional) breeder knows the answer of course: keep anything which looks different because it may contain valuable genes not contained in the average or main types. For an Aguaruna cultivator, the guiding principle might not be too different.

We thus should not take an entirely utilitarian approach: many characters are useful for distinction, but do not automatically mark an important functional difference. Selection is working first on the level of perception, and only second on the level of utilization. SPD provides the farmer with the raw material to work with. In a subsistence production system, such as the one prevailing in sweet potato farming in the New Guinea highlands, these are important considerations. There are multiple uses of sweetpotato, and the goal is not to select the best one, but to get an appropriate, well-performing mixture of cultivars. It is a matter of how much of which variety. Intentional selection for distinctive properties takes place, but so does unintentional selection because the favored variety is not available. This is an indigenous (and still autonomous) mode of variety selection. It is indigenous because it is mostly driven by subsistence needs, and to a very little extent by market forces, and it is

autonomous because varieties are of local stock, as opposed to variety introductions from institutional agricultural research.

Conclusion: lessons for conservation and participatory crop breeding?

What we have seen suggests very strongly that farmers have adopted sweetpotato in historically recent times, and used its genetic potential to adapt it to a diverse mountain environment. This knowledge is valuable and relevant because it allows farmers to distinguish varieties and to select for distinct properties. Varietal change and introduction are almost totally determined locally. This is very fortunate, one might say, because farmers, not researchers, are directing variety selection.

However, farmers as everywhere else have to adapt their cultivar inventory constantly, for example to new pests, and have a keen interest in testing superior varieties. Earliness is one of the characters already sought by the farmers we worked with. It is likely that they would readily accept varieties from formal plant research and breeding with such traits if they prove to be locally adapted.

Considering this strong local knowledge in variety evaluation and development, one would like to advocate, following Hardon and de Boef (1993), a symbiotic relationship between formal agricultural research and the local practitioners of crop development in the future. This relationship should ensure both the continued use of local cultivar inventories, and the evaluation of newly introduced material and could be named "curatorship plus participation in variety evaluation".

Curatorship is an aspect intrinsically linked to local crop management. For ages farmers have conserved germplasm with the aim of securing future food supplies. Only recently, with in situ conservation becoming an item of the biodiversity agenda, has a new policy dimension been added to this role. It is often questioned whether farmers will be interested at all in this new role prescribed for them. It is difficult to imagine a role for farmers doing conservation per se except for a few individuals with the soul of a guardian of crops. Ultimately, the viability of this approach will depend on whether or not farmers are accorded a genuine role in crop development. I know of very few examples of such participatory development, conceived as conservation combined with farmer-driven evaluation of traditional and improved crop varieties (Prain 1993). In the case discussed here, farmers could not only be involved at an early stage in variety evaluation, but could also be asked to experiment with seed selections from breeding programs. The populations grown from this seed would contain hundreds of individuals with a broad genetic base. It would be possible for the farmers to look at those in the same way they traditionally look at volunteer seedlings.

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