# Yam and cowpea diversity management by farmers in the Guinea-Sudan transition zone of Benin

**A. Zannou[1,3,*], A. Ahanchédé[1], P.C. Struik[2], P. Richards[3], J. Zoundjihékpon[4], R. Tossou[1] and S. Vodouhè[1]**

[1] Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, 01 BP 526 Cotonou, Benin
[2] Crop and Weed Ecology Group, Wageningen University, Wageningen, The Netherlands
[3] Technology and Agrarian Development Group, Wageningen University, Wageningen, The Netherlands
[4] 06 BP 2083 Cotonou, Benin
* Corresponding author (e-mail: afiozannou@yahoo.com)

Received 31 May 2004; accepted 24 December 2004

## Abstract

The maintenance and utilization of crop genetic diversity is important to ensure food security. The relative importance of yam and cowpea varieties and the influence of the socio-cultural and local economy context on the diversity maintained were analysed in Benin. Whereas the diversity is large, some varieties were rare, other ones on the way of being abandoned or already lost. Socio-cultural as well as economic and agronomic characteristics explained why some of them were still maintained. For example, the early-maturing yam variety Laboko was planted by most farmers to have tubers available in time for religious purposes, and some specific cowpea varieties played a role in the funeral of the parents in law. Farmers' preferences were translated into criteria they use to appreciate varieties. The diversity of the varieties sold on the market and their availability over time reflect farmers' strategies and conservation practices. The large price differences between varieties confirm the variation in quality as perceived by consumers. The most widely grown yam variety, Florido, is available on the market throughout the year but has a very low price. Market price differences among varieties are much smaller for cowpea than for yam. The processes of loss and displacement of some local varieties are described and the need for conservation is addressed. Different factors that may influence the level of varietal diversity in these crops, like the need to synchronize harvesting with high market prices, were analysed in depth. As opposed to mono-disciplinary approaches of scientists to farmers' problems and constraints, farmers show an inter- or trans-disciplinary behaviour and express their preferences through multi-criteria processes.

*Additional keywords*: *in situ* conservation, farmer variety, agro-biodiversity, *Dioscorea* spp., *Vigna unguiculata*, seed systems, market preference, research institution, learning process

## Introduction

The conservation and utilization of crop genetic diversity is important to ensure food security and food sovereignty. Until now, there is little knowledge on how farmers manage this diversity in yam (*Dioscorea* spp.) and cowpea (*Vigna unguiculata*) in Benin and on how they make decisions related to this issue. New varieties from research programmes often are not adapted to the local conditions and therefore do not satisfy farmers' needs. The reason for this is that the perceptions of various stakeholders, including the farmers, have largely been excluded from the process of variety development. To overcome this problem an innovative research approach has to be designed that maps all actors and stakeholders around a technology (in this case variety development) and combines all their knowledge. We therefore conducted a diagnostic study on yam and cowpea diversity management in Benin. The selection of the crops was based on the technographic study and on the contrasts between the two crops, yam being asexually and cowpea sexually propagated. The study aimed at understanding the varietal diversity management practices by farmers and, implicitly, creating a method and a space of dialogue between farmers, researchers and extensionists for participatory technology development and sustainable conservation and use of genetic resources.

Yam is a major root crop and cowpea is a major grain legume in Benin, where both crops play an important part in the daily diet for millions of people. In Benin, yam has important socio-cultural and religious values. The yam varieties in Benin belong to several species, mostly to *Dioscorea cayenensis – Dioscorea rotundata, D. alata,* and *D. dumetorum*. Morphologically and genetically, *D. cayenensis – D. rotundata* is considered a complex of two polymorphic species: the 'white yam' (*D. rotundata*) and the 'yellow yam' (*D. cayenensis*) (Terauchi *et al.*, 1992; Zoundjihékpon, 1993).

Research institutions such as the International Institute of Tropical Agriculture (IITA) in Nigeria (Akoroda, 1998) showed interest in introducing improved varieties they had developed, hoping that farmers would adopt them. In the case of yam, most of the successful development of new varieties remains the work of farmers in Benin. Yam cultivation leads to the degradation of forests and fertile lands. In an attempt to reduce or stop forest clearing, the Research Development team of the National Agricultural Institute of Benin (INRAB) in 1989 introduced the exotic, high-yielding *D. alata* variety Florido into the farming systems of the central part of Benin (Roesch, 1992). The *D. alata* varieties originate from South-East Asia (Aké Assi, 1998).

Benin is also one of the important cowpea growing countries in West and Central Africa (Singh *et al.,* 1997). Cowpea is grown for its grains and young leaves, but has also been used as forage. IITA developed improved cowpea materials and new germplasm lines and distributed them over the country (Singh *et al.*, 1997; Agli *et al.,* 2001). The INRAB research programmes released several improved, high-yielding cowpea varieties, but these did not perform well at farm level and were therefore not adopted (Anon., 1999; 2001).

The current situation for both crops is that there is a wide diversity of local varieties. However, their yields are low and consequently there is a large pressure on land use. Introductions of new varieties by research institutions may not be successful when these varieties have been tested under much higher soil fertility levels than are

common in subsistence farming and only perform well under such conditions. Moreover, in the case of yam, the new varieties may taste poorly and their seed tubers often cannot be stored very well. So new introductions may be unsuccessful, making it necessary to analyse the farmers' preferences. As a result, the specific objectives of this study were:

1. To identify and characterize the genetic diversity of yam and cowpea in the farming systems;
2. To discuss the level and impact of adoption of new varieties released from research institutions;
3. To identify how the genetic diversity of these two crops is managed.

This paper describes the methodology used to conduct this diagnostic study and the local practices of yam and cowpea diversity management. Besides, it analyses the different socio-cultural, economic and agronomic factors playing a role in this diversity management, and assesses specific objectives and research needs for the analytical phase of the research programme to be carried out later.

## Materials and methods

The diagnostic study focused on the diversity management practised by the farmers and on the views farmers hold on the important characteristics in relation to the different ethnic backgrounds, the different levels of land pressure and the different levels of institutional intervention. The studies on both crops included a preliminary study and in-depth studies in different villages. For the location of these villages see Figure 1.

### Villages of study

The criteria that were used to select the villages included extent of yam and cowpea production, the presence of research or level of intervention, land pressure, proximity to regional market and ethnicity. For the preliminary study on yam, the villages Ouèdèmè and Yagbo in the Glazoué District were selected. These two villages were chosen when during the initial interviews the farmers of Ouèdèmè made clear that they had no more yam land in Ouèdèmè and that they had to search for appropriate land in or near Yagbo. Consequently, for the in-depth study Ouèdèmè was replaced by Kpakpaza. The dominant ethnic group of Ouèdèmè and Yagbo is Mahi-Fon and of Kpakpaza it is Idatcha. Severe land degradation and institutional intervention in the yam crop characterize Kpakpaza. The main features of the villages are listed in Table 1.

For the preliminary cowpea study, the village Dani of the Savè District was selected. Farmers of Dani developed an interest in cowpea production and technology development and in participating in projects. Dani benefited from interventions such as varietal introduction, use of chemical and botanical pesticides from non-governmental organizations (NGOs), and projects on the introduction of varieties and technologies. The in-depth studies were conducted in the villages Dani and Diho. Their characteristics are listed in Table 1.

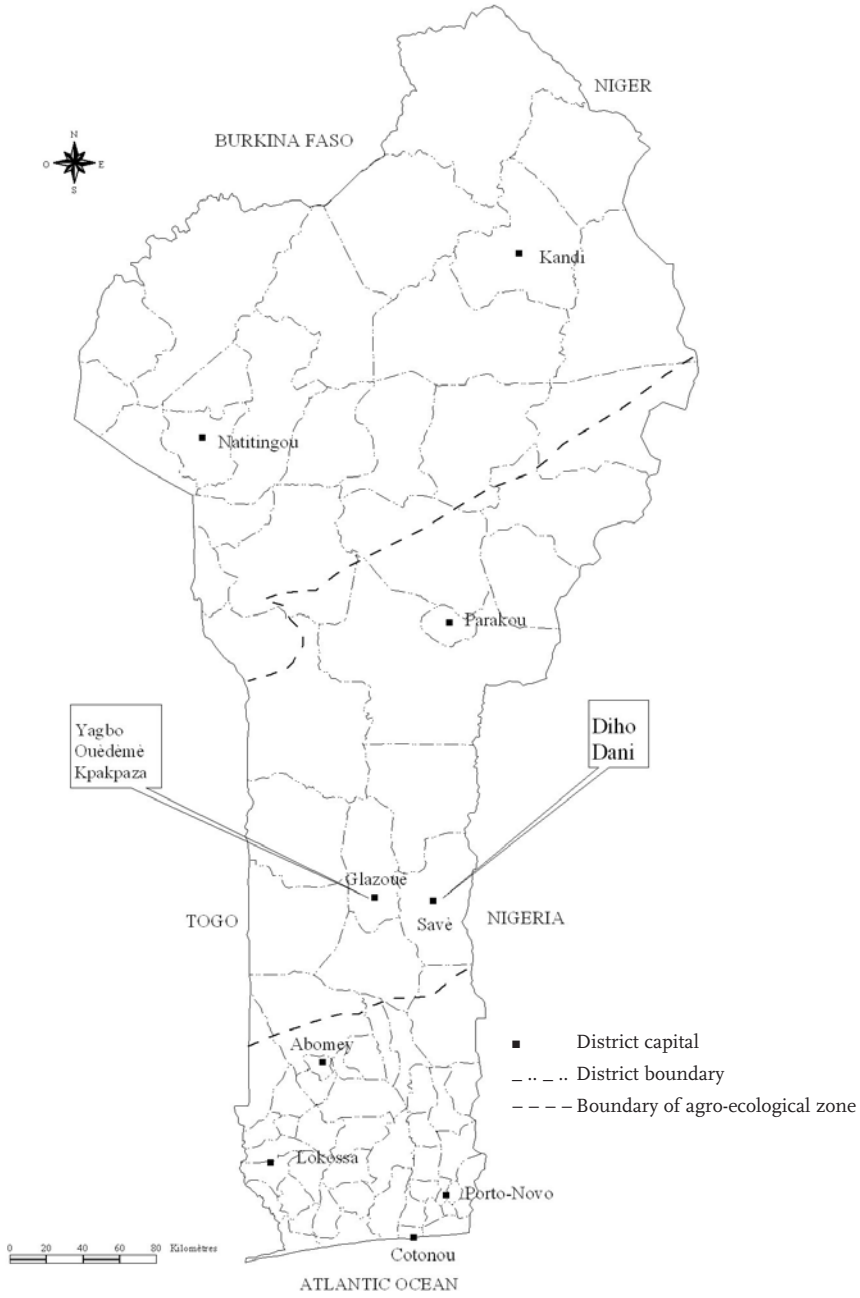


Figure 1. Map of the Republic of Benin, indicating the agro-ecological zones and the villages where the diagnostic study was carried out.

The selected villages lie in the transitional climatic Guinea-Sudan zone between 7° and 10° north latitude. Annual rainfall varies between 1100 mm and 1200 mm. The natural vegetation is mainly tree savannah. The average monthly minimum temperature is 22 °C and the average monthly maximum is 32.8 °C (unpublished data from ASECNA-Benin over the years 1960–1997 for Savè). The yearly average relative humidity is 60%.

Table 1. Characteristics of the villages where in-depth research was conducted on yam and cowpea.

| Characteristic | Yam farming system | | Cowpea farming system | |
|---|---|---|---|---|
| | Kpakpaza | Yagbo | Diho | Dani |
| Distance from district centre (km) | 6 | 30 | 4 | 8 |
| Dominant ethnic population group | Idatcha | Mahi | Tchabè | Idatcha |
| Land colonization | Old | Recent | Old | Recent |
| Land pressure/degradation | High | Low but increasing | Low but increasing | High |
| Level of institutional intervention in the crop | High | Low | Low | High |

## Selection of farmers and data collection

In each of the five villages, a list of farmers growing yam and cowpea was obtained with the help of the village chief and advisors. For the preliminary study, 10 farmers in Ouèdèmè, Yagbo and Dani, and 15 farmers in Kpakpaza and Diho were randomly selected from the list to analyse the place of the crops in the local economy through a pair-wise comparison. During the in-depth phase, 40 farmers were selected in each of the villages Yagbo, Kpakpaza, Dani and Diho to analyse the importance of genetic diversity they hold. Individual and group discussions, field visits and questionnaires were used for data collection. Also key informants and stakeholders were consulted.

Through focus group discussions and through individual discussions with the different ethnic groups in Yagbo and Kpakpaza for yam, 26 criteria were identified to appreciate farmer's variety selection and preference. For cowpea in Dani and Diho, 24 such criteria were identified. These criteria were submitted to and evaluated by 20 farmers (10 men and 10 women) in each of these four villages.

Through recurrent discussions, we reiterated our engagement to ground the research on farmers' knowledge and preferences. Our relationship with the farmers developed into a sort of contract, based on mutual benefits. Such contracts with farmers appear as pre-requisites for joint learning and platform generation and form the frames on which the research trials and activities are developed.

## Socio-cultural aspects

We identified relevant socio-cultural aspects by interviewing individuals and groups to

obtain a good understanding of the relationships between the culture of the ethnic communities of the villages under study and the maintenance of varietal diversity in their farming systems. Not all known rituals were found in each study village. So in addition to individual and group discussions with the ethnic group communities in the study village, it was sometimes necessary to go and discuss with members of the community in other villages where a particular ritual did take place.

### Market choice and data collection

The regional market of Glazoué was selected to study the market dynamics and the diversity management within the area. The prices of the different yam and cowpea varieties sold on this market were collected regularly in the period January–July 2003. The beginning of this period coincides with the time when all yam varieties have reached maturity and can be harvested and sold on the market, and ends when all harvested yam varieties become scarce and the first newly harvested variety (Laboko) appears on the market. So this period gives a good idea of the yam diversity sold on the market and the development of the price over a whole cycle of market availability. This period also provides the range of cowpea varieties that are sold on the market. In June, the early-maturing cowpea varieties grown during the first rainy season appear on the market.

### Collection and analysis of data

The pair-wise ranking method (Russell, 1997) was used to analyse the position of yam and cowpea in the local economy. A matrix table of all crops grown in each village was constructed. Farmers were asked to compare each crop with each of the other ones in terms of values (consumption, market, cultural, etc.) and priority each farmer gives to the crop. All possible combinations were made. The number of times a crop was found to be more important was recorded for each individual farmer. This value represents the individual score for each crop. The scores for each crop were then aggregated over the farmers participating in the exercise. This aggregated score represents the village score. The ranking of these village scores is a measure of the crop's position in the local economy. The same procedure was applied to the criteria farmers in the villages Yagbo, Kpakpaza, Dani and Diho use for variety choice.

Frequency distributions were used to analyse variety diversity per farmer and area share of each variety. Local taxonomy, name and its meaning were used to identify each crop variety. The Spearman's rank correlation test was used to test the consistency of farmer ranking of criteria for selection and preference.

The market prices of each variety were analysed for each month during the period January–July 2003.

## Results and discussion

### Actual yam diversity management

*Yam production: area, diversity and constraints*

The pair-wise comparisons of crops by farmers in Ouèdèmè and Yagbo show that in Ouèdèmè yam ranked second in the local economy after maize and fourth in Yagbo (Table 2). The farmers' logic behind this result is that even though the diversity in yam enables farmers to have their needs satisfied in different periods of the year, from April to mid–July there is yam scarcity. During this period, farmers lack yams that are used for pounding. In contrast, maize can be consumed and conserved during the whole year.

Table 2. Crops and their rankings on the basis of pair-wise comparisons by 10 farmers in the villages Ouèdèmè, Yagbo and Dani, and by 15 farmers in Kpakpaza and Diho.

| Crop | Ouèdèmè | Yagbo | Dani | Kpakpaza | Diho |
|---|---|---|---|---|---|
| Maize | 1 | 1 | 2 | 1 | 1 |
| Yam | 2 | 4 | – | 2 | 5 |
| Cashew | 3 | 2 | 1 | – | 2 |
| Rice | 4 | 7 | 8 | 3 | 10 |
| Cassava | 5 | 3 | 2 | 4 | 8 |
| Cowpea | 6 | 5 | 5 | 7 | 3 |
| Red pepper | 7 | 10 | 10 | 9 | 4 |
| Cotton | 8 | – | – | – | – |
| Onion | 9 | – | – | – | – |
| Sorghum | 10 | – | – | – | 9 |
| Groundnut | 10 | 8 | 4 | 6 | 6 |
| Soya bean | – | 5 | 7 | 5 | – |
| *Egusi* | – | 9 | 8 | 10 | 7 |
| Bambara groundnut | – | – | 6 | 8 | – |

The relative importance of yam varieties in the farming systems of the villages Yagbo and Kpakpaza is shown in Figures 2 and 3. In Yagbo, more than 50% of the farmers grew Laboko, Anago, Ala N'Kodjéwé, Kokoro and Florido. In terms of total cultivated area, Florido is the dominant variety. The mean area cropped to each variety was about 0.90 ha (SE = 0.27). However, most of the varieties grown are held on a small area. In Yagbo 75% of the varieties occupied only 14% of the total area cropped to yam (Figure 2). In Kpakpaza, most farmers grew Laboko, followed by Gnidou and Florido. These three varieties were grown at the largest scale (Figure 3). On average, each variety occupied 1.56 ha (SE = 0.52). However, 75% of the yam varieties occupied only 25% of the total area cropped to yam.

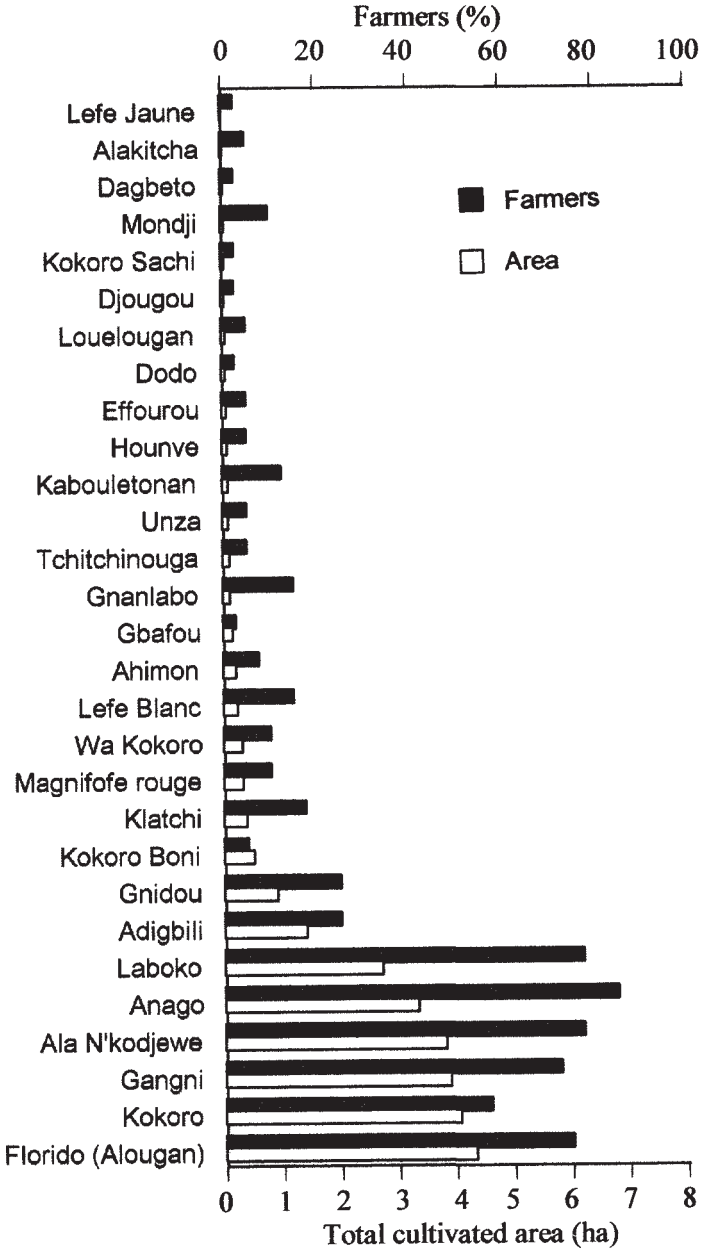


Figure 2. Yam varieties, total cultivated area per variety and proportion of farmers (n = 40) growing a particular variety in Yagbo.

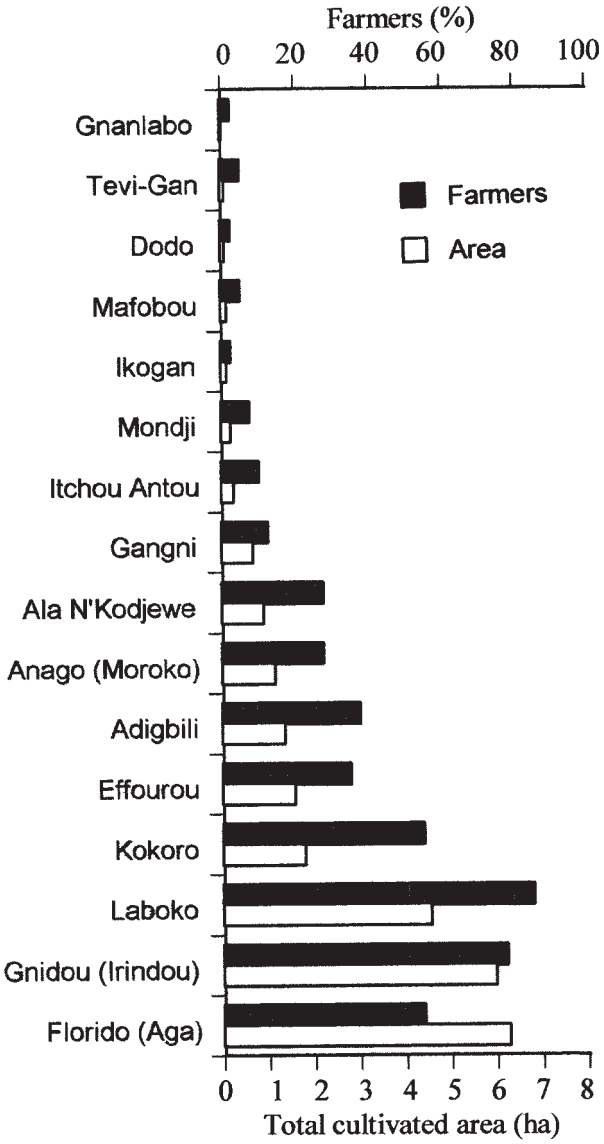


Figure 3. Yam varieties, total cultivated area per variety and proportion of farmers (n = 40) growing a particular variety in Kpakpaza.

In Yagbo, on average 6.4 (SE = 0.39) varieties were grown per farmer. Some farmers grew up to 13 varieties at a time (Figure 4). In Kpakpaza, on average 4.5 (SE = 0.26) varieties were grown per farmer, with some farmers growing up to 8 varieties.

New varieties, developed by a formal institution, are only introduced from international organizations such as IITA. From extensive discussions with researchers testing yam varieties, extension workers and farmers it became apparent that these new introductions are generally of little use. They argue that the main constraints on yam production are the crop's high demand for labour and fertile land, and the lower quality and taste of pounded yam following the use of inorganic fertilizers. Especially the latter is usually considered important in yam diversity management. In fact, while the first harvest of the early-maturing varieties satisfies farmers' food needs after the long period of scarcity, the second harvest only serves to collect seed tubers for the next crop. So it is necessary for farmers to plant late-maturing varieties to assure food security during the dry season. Late-maturing varieties are only harvested once, with the large tubers being used for consumption and the small ones as planting material for the next crop. Farmers choose their varieties by taking into account factors that may significantly influence not only yield, but also their management practices (time of planting, conditions and duration of storage, seed practices, the availability of seed tubers and tubers for consumption and for sale) over the whole year. Farmers define

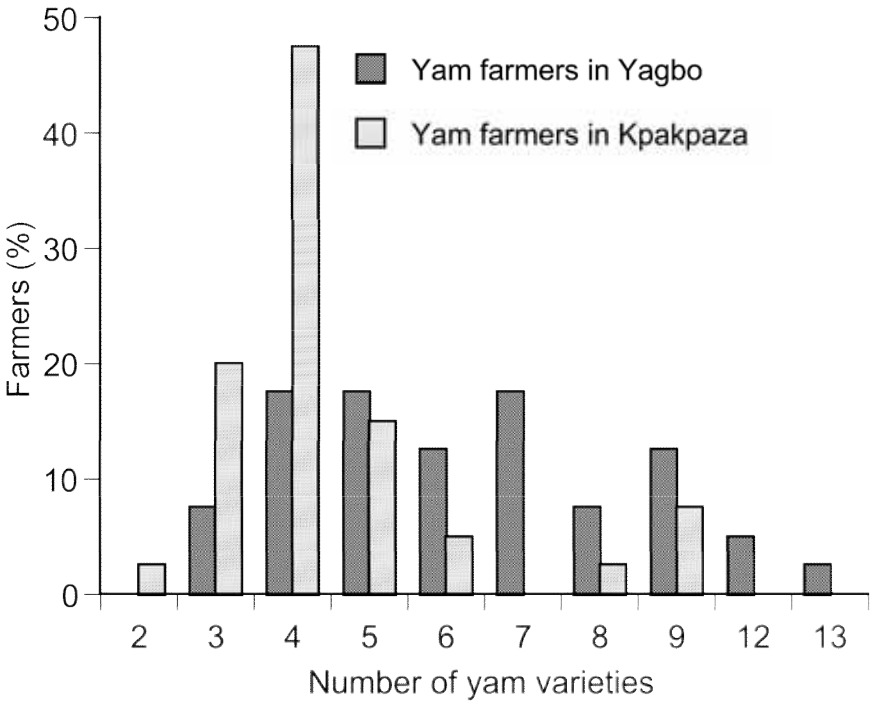


Figure 4. Percentage of farmers in Yagbo (n = 40) and in Kpakpaza (n = 40) growing 2, 3, up to 13 yam varieties.

their objectives in selecting and maintaining the different types (two harvests for early- and one harvest for late-maturing varieties) and the number of varieties that assure food security in the household throughout the year.

Several constraints may contribute to the reduction of diversity. These may include climatic and agricultural risks, the high costs of seed tubers, loss of varieties, lack of fertile land, and insufficient labour capacity of the farmer.

### *Yam domestication knowledge*

Yam domestication is a farmer-managed process of transforming wild yam genotypes into cultivated varieties and maintaining these newly domesticated varieties in the farming systems. Yam domestication is based on farmer's knowledge and increases the level of diversity we may find at farm level. Farmers of Kpakpaza and Yagbo are experienced yam domesticators. They state that the duration of the domestication process varies from 3 to 5 years. During this process, farmers try to transform the elongated shaped tuber of the wild variety into a big rounded one that does not enter deep into the soil. To maintain during the process the size of the tubers at the desired level, farmers place obstacles such as pieces of pottery in the mound. Water content and taste change during the domestication process. In Kpakpaza, the variety Itchou Antou is an example of a successful domestication process, which was managed by a farmer called Antoine, 34 years ago. In Yagbo, 12 farmers were identified who had been involved in domestication. Eight are still practising it, two abandoned it because of having enough varieties, and two because the result was not successful.

The variety Ala is maintained by 50% of these domesticator farmers, Laboko by 33%, Anago by 16%, and Mondji and Kaboulètonan by 8%. Sixteen per cent of the farmers maintained varieties that had no name. Considering the fact that domestication usually results in varieties resembling the already known ones, farmers of Yagbo village raised the question whether the wild yams are really wild or whether they are the result of an evolutionary process transforming cultivated varieties into wild ones. They saw this hypothesis supported by the fact that in olden times their ancestors already cultivated the area.

The presence of forest reserves is important for *in situ* conservation of wild yams. From a domestication point of view Kpakpaza and Yagbo differ in this respect. Yagbo still has forest and bush reserves where wild yams are found to which its farmers have easy access.

### *Socio-cultural values and farmers' preferences*

In the Mahi-Fon socio-cultural communities where the diagnostic study on yam was carried out, the term *alougan* represents the species *D. alata*. *Alougan* means 'the king of the dry season'. The complex species *D. cayenensis - D. rotundata* is named *tévi* or 'upright yielding plant'. Such local names help scientists and also farmers to easily identify the characteristics of the landraces. *Tévi* was domesticated from the wild yams *D. abyssinica* and *D. praehensilis* by West African farmers in the beginning of agriculture in the region.

Yam tubers are used for several types of food: pounded, prepared, peeled and dried yam, and *wassa-wassa*, a type of couscous made from yam cossettes flour. The varietal

diversity is related to these diverse needs.

Yam diversity satisfies several religious and healing values. In the Mahi-Fon ethnic community each household believing in divinities has the obligation to give the first harvested yam as food to their divinities (locally called *fâ* or *vodouns*, i.e., twins) and to their ancestors for having protected the household and the community during the past year. Also the *fâ*-officiating priest (*bokonon*), who is consulted on what to do when a family member is in difficulties, is given yam. To fulfil these duties, each household has to plant the early-maturing yam variety Laboko. Every year, from 14 July, as soon as each variety reaches its physiological maturity and is ready for preparing pounded yams, tubers are harvested to satisfy these ritual duties. Eating pounded yams is part of the culture in several communities in the study area.

Within the Mahi-Fon community it is tradition that all ancestors of this community meet each year on 15 August to celebrate a festival of eating the first pounded yams. This festival is also an occasion for policy-makers to meet and express their attachment to the large Mahi-Fon community.

In the Idatcha community, planting different early-maturing pounded-yam varieties plays another, protecting role. Some yam cultivation practices may involve risks of insecurity. During harvesting or when seed tubers stored under branches or leaves are being evaluated for planting, the risks of being attacked by snakes or scorpions are very high. In Kpakpaza, *Kokoti* (a medicine or fetish imbued with power, as a spiritual force that establishes a protective sphere around those prepared to sacrifice to it or serve it) plays the role of convent of preventive or curative treatment. During the ceremony of *Kokoti*, only the pounded-yam varieties Laboko, Gangni and Mondji are accepted. Kokoro and Dodo are not used. As long as this ceremony has not taken place, the chief of *Kokoti* cannot eat pounded yam, risking nullifying the beneficial effect of *Kokoti*. During the ceremony of *Kokoti*, each household of the community has the duty to harvest yam to offer to *Kokoti* on the day of the ceremony. The above makes it necessary for each household of that community to plant those particular varieties.

When a farmer starts to become interested in yam production on a permanent basis, (s)he progressively acquires an increasing quantity of seed tubers so that (s)he is able to plant. Having sufficient planting material is seen as constituting a patrimony of yam 'seed'. The constitution of this patrimony involves developing social networks. These comprise the parental relations: one can receive the planting material as inheritance or as a gift from his father, mother or uncle. Some friends exchange seed tubers, receive them as a gift or purchase them from each other. The exchange of planting material also goes via labour relations between farmers of different communities within the same village, and between villages, regions or countries.

Farmers have very specific preferences for yam varieties. The ranking of the relevance of the different characteristics was consistent (Spearman ranking test; $R^2 = 0.77$; $n = 24$ for the two villages investigated) (Table 3). Adaptation to soil fertility, resistance to abiotic and biotic stresses, earliness, the possibility to store and pound the tubers and the market price are the most important characteristics determining the choice of a specific variety.

Table 3. Criteria for maintaining yam varieties in Yagbo and Kpakpaza and their rankings on the basis of pair-wise comparisons by farmers. n = number of farmers.

| Criterion | Yagbo (n = 20) | | Kpakpaza (n = 20) | |
|---|---|---|---|---|
| | Total score | Ranking | Total score | Ranking |
| Adapted to poor soils | 402 | 1 | 354 | 5 |
| Resistant to pest and diseases | 391 | 2 | 339 | 7 |
| Market value | 387 | 3 | 353 | 6 |
| Earliness | 383 | 4 | 400 | 2 |
| Tubers suitable for pounding | 382 | 5 | 329 | 8 |
| Number of harvests per year | 366 | 6 | 368 | 4 |
| Rate of emergence | 366 | 6 | 318 | 9 |
| Storability of tubers | 351 | 8 | 407 | 1 |
| Resistant to heat and drought | 339 | 9 | 392 | 3 |
| Days from planting to emergence | 338 | 10 | 299 | 10 |
| Weight of individual tuber | 281 | 11 | 232 | 15 |
| Tubers suitable for boiling (taste) | 264 | 12 | 224 | 16 |
| Tubers suitable for making *cossettes*[1] | 264 | 12 | 174 | 19 |
| Easy harvesting (less labour and breaks) | 210 | 14 | 286 | 11 |
| Period of harvesting | 199 | 15 | 261 | 13 |
| Number of tubers per plant | 194 | 16 | 242 | 14 |
| Healing value | 187 | 17 | 270 | 12 |
| Tuber weight | 173 | 18 | 174 | 19 |
| Tubers suitable for frying | 171 | 19 | 175 | 18 |
| Need for large mounds | 149 | 20 | 137 | 22 |
| Need for large planting material | 143 | 21 | 160 | 21 |
| Tuber length | 135 | 22 | 107 | 24 |
| Colour of tuber flesh | 124 | 23 | 117 | 23 |
| Smoothness of tuber skin | 113 | 24 | 94 | 25 |
| Need for care during growth | 99 | 25 | 214 | 17 |
| Non-forking tubers | 89 | 26 | 74 | 26 |

[1] *Cossettes* = small tubers or pieces of tuber that are pre-cooked and dried.

### *Dominance of the D. alata variety Florido in the farming systems*

While the *D. alata* variety Florido (Alougan from Ivory Coast) became very popular, the local *D. alata* varieties Landou, Hounvè and Sonouko were abandoned. None of the respondents grew them anymore. Discussions with farmers provided information on the determinant factors for maintaining Florido in their farming systems. In general, in the area of study, if forest or fallow land is cleared, the first crop to be grown is yam as it is demanding very fertile soils. However, from the discussions with farmers it became apparent that Florido is adapted to a wide range of soils including poor soils. Florido can be grown on land after successive other crops. It has a high reproductive

capacity and can be grown on several types of mound (small, medium, big). It is less demanding in propagation material as any part of the tuber can be used. Its seed tubers have a relatively high emergence rate and Florido is also adapted to cropping systems where inorganic fertilizers are applied, like in the cotton cropping systems. Its harvest appears relatively easy and the tubers can be stored for a relatively long period. Its current dominance on the regional market of Glazoué is remarkable (75–98% of the yam volume sold).

## Farmers' actual choice of cowpea varieties

### *Cowpea production area, diversity and constraints*

In the local economy of Dani, cowpea is both food and cash crop. Cowpea ranked fifth after cashew, cassava, maize, and groundnut, based on the pair-wise comparison (Table 2).

In Dani more than 50% of the farmers grew the cowpea varieties Tawa gros grain and Moussa. These two varieties were grown at the largest scale, 12.3 and 12.2 ha respectively (Figure 5). However, 75% of all cowpea varieties were grown on less than 25% of the total area cropped to cowpea. On average, farmers grew 2.85 (SE = 0.23) varieties at a time (Figure 6), but some grew up to 8 varieties.

In Diho the varieties Tawa gros grain and Mata were grown by 80 and 40% of the farmers, respectively (Figure 7). The other varieties, representing 77% of the ones grown, were grown at the smallest scale (29% of the total area cultivated). On average, one farmer had 1.7 (SE = 0.17) varieties at a time (Figure 7), but some grew up to 4 varieties.

In both villages, early- and late-maturing varieties were grown.

### *Socio-cultural values and farmers' preferences*

Cowpea, apart from being sold on the market, is used for home consumption. Its seeds are cooked (*abobo*) or used for preparing cake (*ata* or *ikra*) and doughnuts (*abla*, *ihayahaya*, *adjabla*, *tchohounbo*, *lèlè*), and its young leaves serve as a vegetable. The crop is also used as green manure. In the past, cowpea hay and foliage were used as animal feed but nowadays these uses are no longer common because of the massive use of pesticides for crop protection.

Atama and Djètoko are said to be local varieties. They are used on the occasion of the funeral of the parents in law. The variety Kpohoundjo produces lots of leaves and is used as green manure. Tawa is appreciated for the preparation of *doko* because its hilum is white and without any mark. Atama, Djètoko, Egniawo, Téhoundé, Moussa, and Kpohoundjo are appreciated for making doughnuts because the grains are very large and provide a good mixture with maize flour or cassava meal. The local variety Mata has a high healing value. In Diho village, farmers use Mata to treat abscesses and the sickness caused by the Guinea worm (*Dracunculus medinensis*).

For new plantings farmers use seeds from different sources, but they usually save seeds from the previous harvest or buy them from the market. Other farmers use their social relations for obtaining seeds from their relatives or friends.

Farmers' preferences for cowpea varieties are very specific. The ranking of the rele-

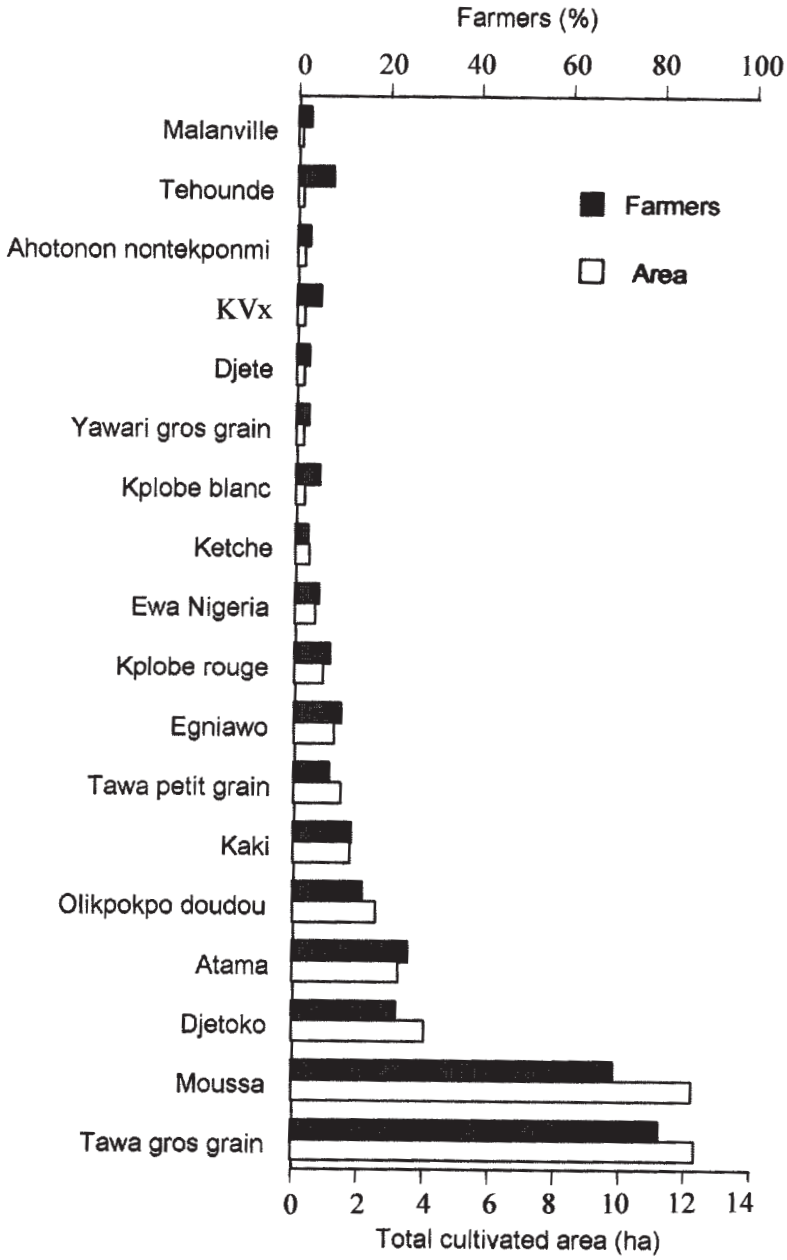


Figure 5. Cowpea varieties, total cultivated area per variety and proportion of farmers (n = 40) growing a particular variety in Dani.

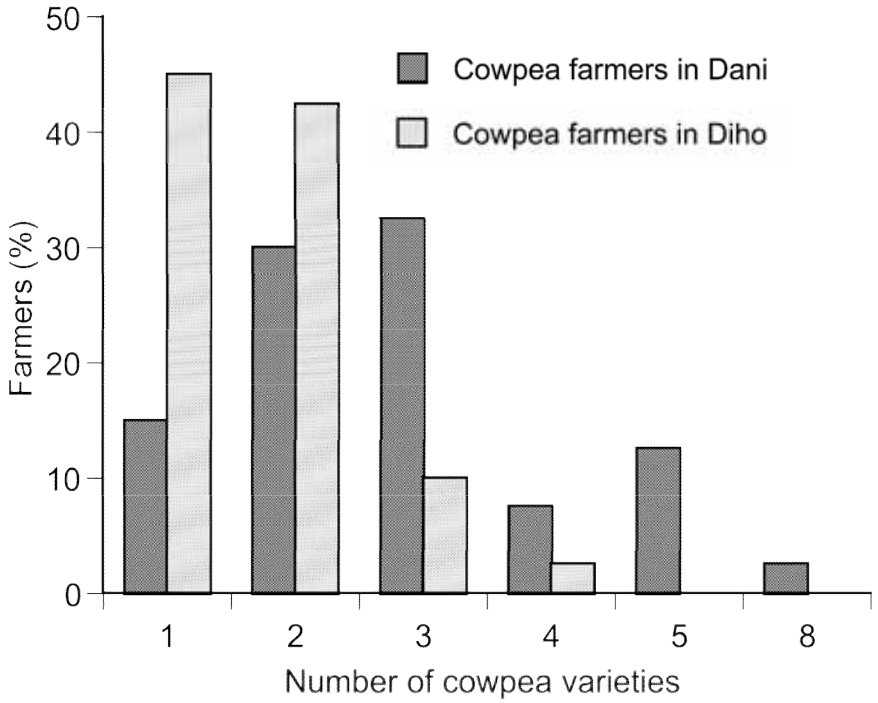


Figure 6. Percentage of farmers in Dani (n = 40) and in Diho (n = 40) growing 1, 2, up to 8 cowpea varieties.

vance of the different characteristics is consistent (Spearman ranking test; $R^2 = 0.74$; n = 24) for the two villages investigated (Table 4). The most important varietal traits are the harvest and post-harvest characteristics, followed by yield, resistance to pests and diseases, and healing value.

Farmers in Dani indicated that most of the introduced improved varieties are highly susceptible to pests and diseases during growth and to post-harvest pests. Nowadays, the local varieties are no longer excluded from the resurgence of these pests and diseases. An analysis of the situation showed that the compulsory use of chemical pesticides on cowpea is inherently linked to the recent development of cotton pests. Many insect pests may recently have shifted from cotton to cowpea, as the pesticide use in cotton fields is heavy. It was also observed that cowpea fields are adjacent to cotton fields, which may enhance this shift. The pesticides for cowpea advised by extensionists are beyond reach for the farmers. IITA advised farmers of Dani to apply botanical pesticides, but farmers realized that the use of botanical pesticides is more labour demanding and relatively inefficient, compared with the synthetic pesticides that they used to apply on cowpea.

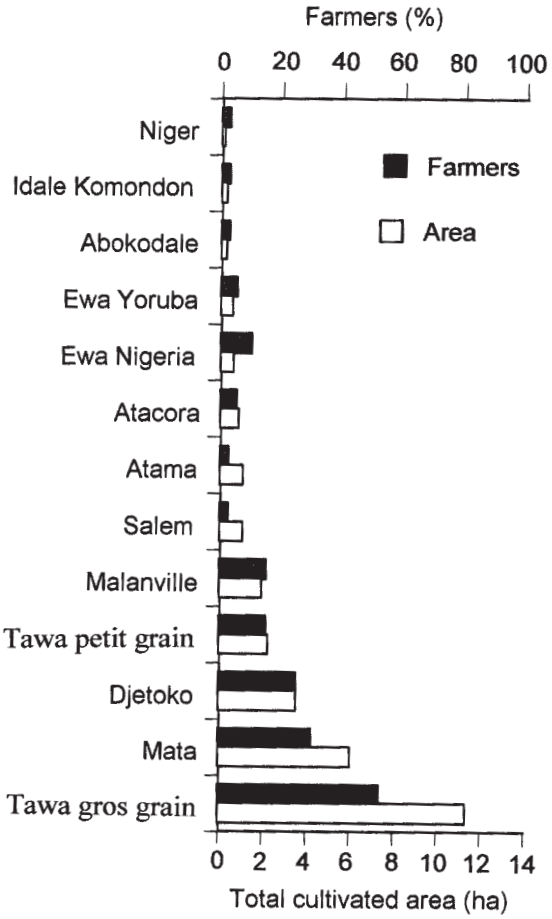


Figure 7. Cowpea varieties, total cultivated area per variety and proportion of farmers (n = 40) growing a particular variety in Diho.

## Market dynamics of yam and cowpea varieties

### *Yam market*

The yam market is characterized by high diversity. Of the 24 different yam varieties that appeared on the market in the period January–July 2003, 22 belonged to the *D. cayenensis – D. rotundata* complex, one to *D. alata* (Florido), and one to *D. dumetorum*. In terms of frequency of yam varieties on the market of Glazoué from January to July, we distinguish three groups. The first group consists of varieties that are sold almost on every market day (Florido, Gnidou and Kokoro). During the period January–July they appeared on 74–84% of the market days. Florido and Gnidou were on the market

Table 4. Criteria for maintaining cowpea varieties in Dani and Diho, and their rankings on the basis of pair-wise comparisons by farmers. n = number of farmers.

| Criterion | Dani (n = 20) | | Diho (n = 20) | |
|---|---|---|---|---|
| | Total score | Ranking | Total score | Ranking |
| Storability of the seeds | 374 | 1 | 345 | 2 |
| Yield | 330 | 2 | 345 | 2 |
| Resistant to pests and diseases | 329 | 3 | 323 | 4 |
| Pods easy to shell | 323 | 4 | 268 | 12 |
| Easy to harvest | 316 | 5 | 287 | 8 |
| Healing value | 314 | 6 | 361 | 1 |
| Seeds easy to winnow | 296 | 7 | 272 | 9 |
| Resistant to drought | 293 | 8 | 304 | 6 |
| Tolerant of excessive rainfall | 290 | 9 | 270 | 10 |
| Tolerant of weeds | 264 | 10 | 312 | 5 |
| Number of crops per year | 254 | 11 | 265 | 13 |
| Earliness | 251 | 12 | 292 | 7 |
| Market value | 241 | 13 | 258 | 14 |
| Resistant to bird damage | 231 | 14 | 151 | 20 |
| Number of harvests per crop | 219 | 15 | 270 | 10 |
| Taste of seeds after cooking | 207 | 16 | 215 | 15 |
| Seeds suitable for preparing *abobo*[1] | 197 | 17 | 191 | 16 |
| Cooking duration | 162 | 18 | 118 | 21 |
| Smell during or after cooking | 160 | 19 | 172 | 18 |
| Seeds suitable for preparing *abla*[1] | 143 | 20 | 176 | 17 |
| Seeds suitable for preparing *ata*[1] | 127 | 21 | 167 | 19 |
| Seed size | 92 | 22 | 68 | 24 |
| Seed colour | 73 | 23 | 73 | 23 |
| Hilum colour | 34 | 24 | 76 | 22 |

[1] *abobo*, *abla* and *ata* are local dishes.

till July, and particularly Florido till the new harvest of Laboko appeared. The second group consists of varieties that during the period January–July were sold on 39–68% of the market days (Anago, Laboko, Ala, Gangni, and Klatchi). They appeared on the market till the end of April. The third group consists of varieties that are only incidentally found on the market.

Varietal characteristics determine the market price (Table 5). Laboko fetches the highest price. It is essentially designated for pounded yam. Kokoro is essential for preparing peeled and dried yam. Florido appeared and began dominating the market since February, but fetched the lowest price. Kokoro and Florido are both designated for making peeled and dried yam. The price of Kokoro was more than double the price of Florido. Although the price of Gnanlabo was second highest after Laboko, Gnanlobo

Table 5. Yam varieties sold on the market of Glazoué, and the ranges of their average price over the period 1 January – 30 July 2003.

| Price range (F CFA $kg^{-1}$) | Yam species and varieties |
|---|---|
| | *Dioscorea cayenensis – D. rotundata* |
| 190–200 | Laboko |
| 150–160 | Gnanrabo (Gnanlabo), Okogan |
| 120–130 | Moroko (Anago) |
| 110–120 | Klatchi, Dodo |
| 100–110 | Gangni (Cangni), Ala N'Kodjèwé, Adigbili, Amoula, Kablètonan, Kokouma, Mondji, Sotobowa |
| 90–100 | Mafobou, Effourou, Irindoun (Gnidou), Ahimon / Arimon, Ikinni, Okoékojè, Kokoro |
| 80–90 | Agatou |
| | *D. dumetorum* |
| 80–90 | Essourou / Eréfé |
| | *D. alata* |
| 30–40 | Florido (Aga / Alougan) |

is rare on the market, which reflects its situation in the farming system. Gnanlabo demands specific fertile land, which is becoming rare in the area of study.

### *Cowpea market*

Also the cowpea market is characterized by a high diversity. The most frequently sold varieties (71–100% of the market days) during the period January–July 2003 were Egni-awo, Aïglo and Kaki, of which Egni-awo was available on all market days. The second group composed of Tawa, Malanville and Kplobè. They were present on 29–55% of the market days. Djètoko fetched the highest price, whereas during this period Boto and Kaki got on average the lowest price (Table 6).

As for cultural preferences, the cowpea market is socio-ethnically orientated. The farmers of Dani mainly direct their strategies towards growing cowpea varieties that satisfy the preferences of regional markets. Varieties with white seeds are grown predominantly for the Glazoué and Savè markets (Yoruba / Nagot zone), and varieties with red seeds are for sale on the Bohicon and Abomey markets (the Mahi-Fon ethnic group zone). Varieties with black seeds are the least grown and are mainly intended for home consumption. In Diho village, the preferences become more and more based on the early-maturing white-seeded types to satisfy urgent financial needs. With such varieties farmers have the possibility to grow two cowpea crops per year.

Table 6. Cowpea varieties sold on the market of Glazoué, and the ranges of their average price over the period 1 January – 30 July 2003.

| Price range (F CFA per *tongolo*[1]) | Varieties |
|---|---|
| > 210 | Djètoko, Olikpokpodoudoun, Ewa Egbessi |
| 190–210 | Malanville |
| 170–190 | Noukoun vovo, Wankoum, Aïglo, Tchadjilé-djofè, Matamariko, Tawa / Dani, Egniawo, Togo-grain |
| 150–170 | Moro, Mahouna, Kplobè, Kaki, Boto |
| < 120 | Atama |

[1] *Tongolo* is a local, cubic measure. On average, one *tongolo* of cowpea is about 1 kg.

### *Temporal availability of yam and cowpea varieties*

Figure 8 shows the temporal availability of yam and cowpea diversity on the market of Glazoué over the period 1 January – 30 July 2003. From this figure it appears that most varieties of both yam and cowpea are sold during the dry season, in the middle of March. Thereafter there is a decrease in the number of varieties sold. This trend reflects the situation in the households during that period. May is usually perceived as the 'month of starvation'. In June the early-maturing cowpea varieties appear on the market. The end of July is marked by the ritual entry of the earliest-maturing yam variety, Laboko.

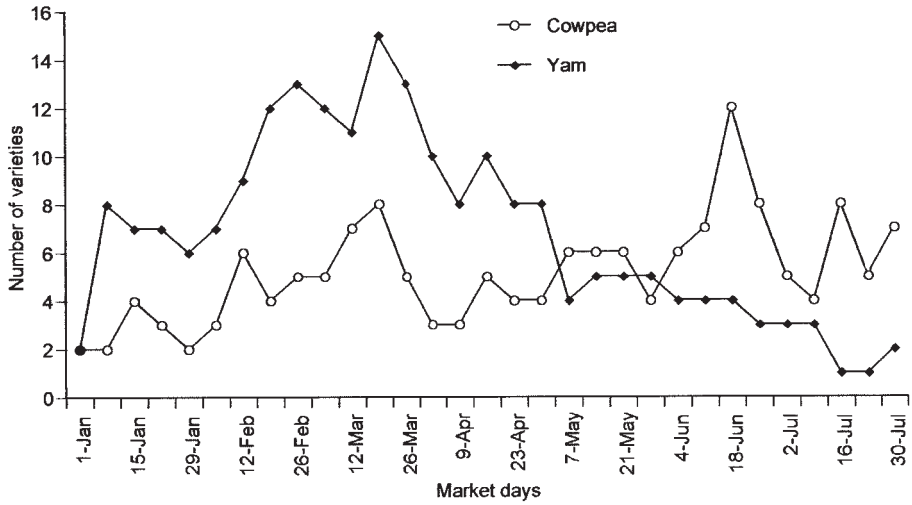


Figure 8. Temporal availability of yam and cowpea varieties on the market of Glazoué, in the period 1 January – 30 July 2003.

## Discussion

### Adoption of formal varieties bred outside Benin

For both yam and cowpea, the introduction of formal varieties bred by international organizations and introduced through the national system of variety testing is unsuccessful. Discussions with local stakeholders learned that adoption will not take place as long as there is no close communication between the farmers and the breeders. The idea farmers have about the ideal crop for their conditions strongly differs from the ideotype breeders look for, and that is bred under completely different agronomic circumstances and does not take into account the way the harvested products are used locally.

### Importance of local varieties

Our preliminary results show the existence in the farming systems of several local yam varieties that satisfy the food, religious and economic needs of the farmers and that meet the increasing demand for pounded, fried, peeled and dried yam. Of the 33 yam varieties identified, Florido is the only exotic recently introduced variety. However, its relative importance and dominance both in the farming systems and on the market is remarkable. Yam domestication is a practice that improves the level of yam diversity in Benin (Dumont & Vernier, 2000; Tostain *et al.*, 2003).

As for cowpea, of the 25 varieties identified in Dani and Diho only two are improved varieties, which is an indication of the diversity of local varieties in the farming systems in Benin.

### Farmers' preferences

As far as yam is concerned, farmers maintain their desires to satisfy the demand for different yam foods and for timely generating income, in addition to the socio-cultural values they preserve. As for cowpea, according to Anon. (1990), farmers rather prefer early- than late-maturing varieties to solve the problems of periodic shortage and drought. However, farmers express some contradictory needs and make different choices because of factors of economic or market importance. In Dani, farmers also appreciate late-maturing varieties of which the harvesting coincided with the period of higher cowpea prices on the market. This strategy of synchronizing the harvesting time with the high market price enables farmers to avoid investing in supplementary storage costs. So the agronomic performance of cultivated varieties and their suitability to satisfy the household or community needs that the market demands, form the basis of farmers' preferences.

### Market preferences

For yam, Doumbia (1998) showed a price difference according to the species and also found that in Ivory Coast, Florido was the second most marketed yam variety after

Krenglè. This position of Florido in Ivory Coast is due to its high rate of multiplication and its resistance to Internal Brown Spot disease, which attacks and depreciates other varieties of *D. alata*. The conventional economic explanation for the loss of crop diversity on the farm is that such losses are demand-driven. Farmers specialize and displace their diverse set of landraces for high-yielding modern varieties that provide them with a high income (Bellon, 2001). We realized that it is not just the market, but also the non-adaptability of the variety to several uses in the farming systems that plays a role.

On the market, premium prices are paid for varieties with different characteristics. Our study learned that market prices not only differ among crops but also among varieties within a crop. With cowpea, grain colour, grain size, hilum colour and resistance to weevils are important characteristics to consumers. Faye *et al.* (2002) reported similar results for cowpea in Senegal and found that buyers are willing to pay a premium for grain size and white seeds but discount the price for other colours and for the number of weevil holes in the grain. Coulibaly & Lowenberg-De Boer (2002) mention that grain colour and hilum colour are important when the seeds require hulling. The consumer dislikes the flecks that may be left following poor pounding and winnowing after the seeds are hulled.

## Local variety displacement by farmers

In the different interviews farmers often mentioned the process of variety displacement. With yam, a case often stigmatized by farmers themselves is the adoption of the variety Alougan from Ivory Coast (syn. Florido) displacing the local Alougan (Landou). Strategies for genetic resources conservation should be developed and targeted on varieties that are disappearing. We realized that the process of variety displacement can easily occur within a plant species or plant group where two or more varieties with different characteristics are used for the same purpose. Richards (1995) analysed the importance of displacement of African rice (*Oryza glaberrima*) by Asian rice (*O. sativa*) and showed that in Sierra Leone throughout the forest zone *O. sativa* displaced *O. glaberrima* by 90–100%. *O. glaberrima* is low-yielding, but is adapted to pests, weeds, poor soils and drought. Friis-Hansen (1999) analysed the displacement of a diversity of indigenous sorghum landraces by one modern variety and highlighted how local varieties can be threatened by a new introduction. As a response to the 1991/1992 drought in Southern Africa, a non-government organization (NGO) distributed 40 tons of an improved sorghum variety by way of emergency seed supply. After three years it was noticed that the improved variety was grown on 75–90% of the farmers' sorghum fields. Of the 16 local varieties only 11 were still present in the village, confined to the remaining area (Friis-Hansen, 1999).

## Loss of local varieties

Several local varieties have been discarded by farmers, other ones lost or on their way of being lost. Some local varieties are grown on very small plots of land and/or by one or a few farmers only. The total loss of varieties may be accompanied by the loss of

local knowledge related to them. But till now, the indigenous knowledge and utilization of the various varieties have been poorly documented. Some losses are voluntary. The farmer himself may have abandoned a variety because it no longer satisfied his preferences or could no longer cope with agronomic constraints. There are also accidental losses of varieties that have disappeared due to external factors (i.e., erratic rainfall, pests/diseases). Worede (1997) reported on the irreversible losses of sorghum, wheat and maize varieties from the Ethiopian gene pools and concluded that crucial factors are the displacement of indigenous landraces by new genetically uniform crop cultivars, drought, change of land use and destruction of habitats. Ortega (1997) showed that the introduction of improved potato varieties has given rise to genetic loss in many parts of Peru. However, sometimes the introduction of new varieties can locally broaden the genetic base. On the other hand, the loss of a variety at the local level may not necessarily mean a total loss at the regional or national level.

## Farmers' behaviour towards the maintenance of diversity

Several behaviours contribute to maintaining yam and cowpea diversity. Farmers can show innovative behaviour by testing exotic varieties. Some farmers are deviant in being the first in adopting and maintaining new varieties. Dennis (1987) characterized this deviant behaviour as 'contrarian behaviour'. According to Dennis (1987), with 'contrarian variety use' the farmer is either the only one who grows an exotic variety or is one of the few farmers growing such a variety in a given year. These behaviours contribute to the maintenance or to the broadening of varietal diversity. Dennis (1987) argued that the existence of 'contrarian' innovators is central to the idea that farmers consciously maintain the genetic diversity. The 'contrarian' farmer needs to be distinguished from the outright conservative who is slow to adopt new varieties or who is apt to have a lower variety turnover on his farm. He also needs to be distinguished from the modern or directional innovator who tends to discard traditional and other older varieties with new government releases. The case described by Dennis (1987) is related to rice in northern Thailand. For yam and cowpea in Benin, farmers show several behaviours by preserving at the same time the socio-cultural values, the food security over the year, guaranteeing a regular income by taking profit from different varieties with different agronomic characteristics.

Knowing that farmers' behaviour is based on very specific needs, preferences and socio-cultural aspects, co-operative research with farmers becomes necessary to establish new ways of a dialogue between researchers and farmers in evaluating the characteristics of the varieties farmers maintain in their systems.

## On-farm maintenance of agro-biodiversity

The sustainable conservation and utilization of local genetic resources are important issues. In analysing the validity of theories around the issues raised by on-farm conservation of genetic resources, Wood & Lenné (1997) showed that traditional farming has three positive characteristics. The first one is the constant search by farmers for *novel variation* or genetic novelty. The ability of farmers to *experiment* with this vari-

ation is the second characteristic, and the third one is that farmers manage a *dynamic portfolio of varieties*. The result of farmer experimentation is a dynamic, open system of on-farm management of genetic resources, with both recruitment and loss of local varieties. Richards (1989) suggested that farmers' ability to experiment is a neglected resource. Monde & Richards (1994) provided examples of this. Farmers' selection criteria and maintenance practices are not well known by scientists in Benin. Wood & Lenné (1997) concluded that there is a serious lack of specific technical research on on-farm conservation and suggested that it should include a research agenda. They argued that there has been very little institutional research; as a result of past neglect, no agreed set of scientific principles and practices yet exists for on-farm conservation of genetic resources.

The on-farm maintenance of biodiversity requires understanding by the farmer of how specific varieties should be grown, stored and maintained in order to maximally realize the characteristics these farmers value. Therefore a farmer-driven research agenda is necessary for optimal adaptation of these varieties to their cropping system.

## Consequences for future research

The purpose of this diagnostic study was to identify key factors that influence the level of genetic diversity maintained by farmers, and from there to build the critical analytical frame for the in-depth research on biodiversity management in yam and cowpea. The diagnostic study created a common understanding and ground for sharing knowledge on inter-disciplinary issues at an inter-institutional level for the in-depth research. Farmers' research committees have been established and these have indicated several fields of research. Yam farmers indicated that they wanted a better understanding of the performance of seed tubers from different varieties in relation to the part of the seed tuber used (apical, middle or lower part) for propagation. Besides, they wanted information on how seed-tubers of early- and late-maturing varieties should be stored in order to obtain a high emergence rate and vigourous plants. For cowpea, farmers indicated that they wanted more insight into the photoperiodic behaviour of late varieties when planted during the second rainy season. They also wanted higher yields, fewer insecticide applications and the possibility to store the seeds for a long period. For both crops it is needed to test different varieties through participatory variety characterization taking into account farmers' planting dates and agricultural practices.

## Critical reflection on the diagnostic study

The diagnostic study has been helpful in selecting appropriate villages that differ in a number of contrasting characteristics such as the level of institutional intervention in the crop, its ethnicity, land pressure or soil degradation, and its proximity to the regional market or road. These characteristics provide the various contexts in which farmers' motivations change over time and how farmers proceed to face the various

constraints. Issues such as socio-cultural factors (i.e., cosmo-vision) are to be addressed at community levels. It has also been necessary to review the methods and tools for interviewing the farmers in accordance with the issue at stake. The diagnostic phase set the research agenda for the in-depth phase of the research programme, identified the topics of joint learning and created mutual confidence with farmers for the experimental phases. As opposed to mono-disciplinary approaches to farmers' problems and constraints, farmers inter-act with an inter- or trans-disciplinary behaviour and express their preferences through multi-criteria processes (Figure 9). From that analysis of farmer's perspectives, the analytical frame for the in-depth research is constructed. The on-farm experimental phases are based on factors that farmers consider relevant and on how farmers manage different agronomic and genetic variety traits through joint learning. In addition to the informal seed system, other key institutions are supposed to have significant impact on the diversity management practices. The experimental phase is in the nature of sharing issues with market actors, and of planning opportunities of dialogue between farmers, market leaders and other stakeholders such as research institutions, NGOs, and extension services (Figure 10). The importance and influence of these stakeholders in agro-biodiversity maintenance will be critically analysed.

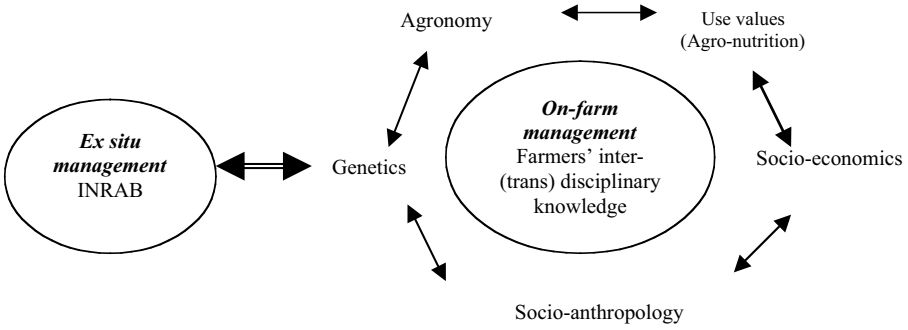


Figure 9. Mapping knowledge on yam and cowpea diversity management practices.

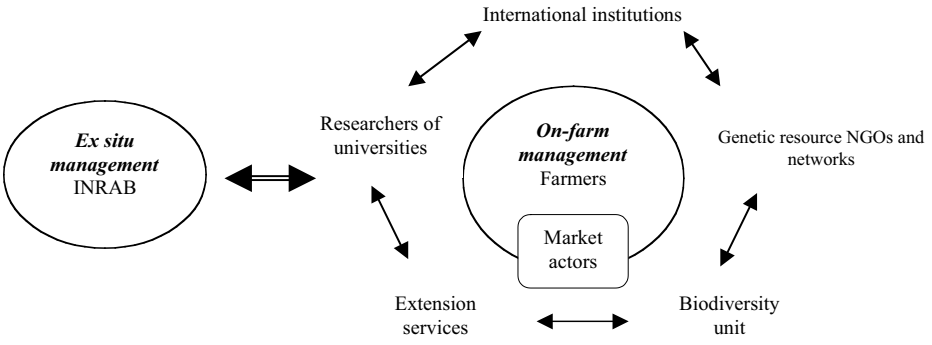


Figure 10. An integrated multi-stakeholder process for yam and cowpea diversity management.

## Concluding remarks

Only a few yam and cowpea varieties found at farm level are considered to be the property of research institutions: two for cowpea and one for yam. The national and international institutions deploy efforts in creating a lot of varieties. Paradoxically, we only found a few at farm level. In other words, their varieties are kept in gene-banks and do not serve farmers. This is a kind of discordance between the efforts of the agricultural research institutions and the actual needs of the farmers.

The different names and meanings farmers give to their varieties are indicative of varietal characterization. Farmers' variety names point to agronomic characteristics, morphology, and genetics. Some farmers are very conscious of the maintenance of the genetic potential in continuing growing varieties that other farmers have already discarded. Farmers' behaviour in the maintenance of yam and cowpea diversity is related to the preservation of the varieties' socio-cultural values, to food security over the year and to the agronomic and economic values of these varieties. Some local varieties have been discarded. The reasons why they were abandoned and their history, the process of variety choice and selection, the socio-cultural preferences, farmers' objectives, the market demand, the conservation practices, and the village seed exchange networks need to be thoroughly documented. It is of national public interest to learn about how farmers manage agro-biodiversity and the different factors that influence this management. The conservation of the national genetic resources has become a priority with the application of the Convention on Biodiversity.

## Acknowledgements

We wish to thank Dr W. Van Der Werf of Wageningen University, Professor Valentin Agbo of Abomey-Calavi University and members of the Convergence of Sciences project for their contribution to the success of this diagnostic study. The assistance and the co-operation of the farmers, the researchers of INRAB, the representatives of the CARDERs and the actors of the NGOs in the study area are gratefully acknowledged.

## References

Agli, C., O. Coulibaly & R. Adeoti, 2001. Adoption des Technologies de l'Utilisation des Variétés Améliorées et des Extraits de Plantes Naturelles pour la Protection de la Culture du Niébé au Bénin. Working Document No 01/2001-SE/BE, Projet Niébé pour l'Afrique (Programa Nacional do Fortalecimento da Agricultura – PRONAF), Benin, 17 pp.

Aké Assi, L., 1998. La diversification des utilisations des ignames: usage pharmaceutique traditionnel. In: J. Berthaud, N. Bricas & J.-L. Marchand (Eds), L'Igname, Plante Séculaire et Culture d'Avenir. Actes du Séminaire International, 3–6 June 1997, Montpellier. Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), Montpellier, pp. 263–273.

Akoroda, M.O., 1998. Genetic selection in food yams: a century of sporadic efforts. In: J. Berthaud, N. Bricas & J.-L. Marchand (Eds), L'Igname, Plante Séculaire et Culture d'Avenir. Actes du Séminaire

International, 3–6 June 1997, Montpellier. Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), Montpellier, pp. 107–117.

Anonymous, 1990. Enquête pour l'Identification des Caractéristiques Recherchées par les Paysans sur les Semences des Variétés Améliorées et de Cultivars Locaux en vue du Développement de l'Utilisation des Semences Vivrières en République du Bénin. FAO/PNUD Projet BEN/84/010-Porto-Novo. Ministère du Développement Rural et de l'Action Coopérative (MDRAC), Cotonou, 121 pp.

Anonymous, 1999. Annual Report 1997–1998. Institut National de Recherche Agricole du Bénin (INRAB), Cotonou, 87 pp.

Anonymous, 2001. Annual Report 2000. Recherche pour le Développement Agricole. Institut National de Recherche Agricole du Bénin (INRAB), Cotonou, 113 pp.

Bellon, M.R., 2001. Demand and Supply of Crop Intraspecific Diversity on Farms: Towards a Policy Framework for On-Farm Conservation. Economics Working Paper No 01-01, International Maize and Wheat Improvement Center (CIMMYT), Mexico, 12 pp.

Coulibaly, O. & J. Lowenberg-De Boer, 2002. The economics of cowpea in West Africa. In: C.A. Fatokun, S.A. Tarawali, B.B. Singh, P.M. Kormawa & M. Tamo (Eds), Challenges and Opportunities for Enhancing Sustainable Cowpea Production. Proceedings of the 3rd World Cowpea Conference, 4–8 September 2000, Ibadan. International Institute of Tropical Agriculture (IITA), Ibadan, pp. 351–366.

Dennis, J.V., 1987. Farmer management of rice variety diversity in northern Thailand. PhD thesis Cornell University, Ithaca, 367 pp.

Doumbia, S., 1998. Quelques aspects actuels de la commercialisation de l'igname en Côte d'Ivoire. In: J. Berthaud, N. Bricas & J.-L. Marchand (Eds), L'igname, plante séculaire et culture d'avenir. Actes du Séminaire International, 3–6 June 1997, Montpellier. Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), Montpellier, France, pp. 285–290.

Dumont, R. & P. Vernier, 2000. Domestication of yams (*Dioscorea cayenensis - rotundata*) within the Bariba ethnic group in Benin. *Outlook on Agriculture* 29: 137–142.

Faye, M., J. Lowenberg-DeBoer, A. Sène & M. Ndiaye, 2002. Identifying cowpea characteristics which command price premiums in Senegalese markets. In: C.A. Fatokun, S.A. Tarawali, B.B. Singh, P.M. Kormawa & M. Tamo (Eds), Challenges and Opportunities for Enhancing Sustainable Cowpea Production. Proceedings of the 3rd World Cowpea Conference, 4–8 September 2000, Ibadan. International Institute of Tropical Agriculture (IITA), Ibadan, pp. 424–433.

Friis-Hansen, E., 1999. The Socio-Economic Dynamics of Farmers' Management of Local Genetic Resources – A Framework for Analysis with Examples from a Tanzanian Case Study. Working Paper No 99.3, Centre for Development Research (CDR), Copenhagen, 44 pp.

Monde, S.S. & P. Richards, 1994. Rice biodiversity conservation and plant improvement in Sierra Leone. In: A. Putter (Ed.), Safeguarding the Genetic Base of Africa's Traditional Crops. Technical Centre for Agricultural and Rural Cooperation (CTA) and International Plant Genetic Resources Institute (IPGRI), Rome, pp. 83–90.

Ortega, R., 1997. Peruvian *in situ* conservation of Andean crops. In: N. Maxted, B.V. Ford-Lloyd & J.G. Hawkes (Eds), Plant Genetic Conservation. The In Situ Approach. Chapman & Hall, London, pp. 302–314.

Richards, P., 1989. Farmers also experiment: a neglected intellectual resource in African science. *Discovery and Innovation* 1: 19–25.

Richards, P., 1995. Farmer knowledge and plant genetic resource management. In: J.M.M. Engels (Ed.),

In Situ Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture in Developing Countries. Report of a DSE / ATSAF / IPGRI workshop, 2–4 May 1995, Bonn-Röttgen. A joint publication of IPGRI, Rome, and DSE, Feldafing, pp. 52–58.

Roesch, M., 1992. La Recherche - Développement dans le Zou: principes d'action et résultats. In: Actes du Séminaire National sur la Recherche – Développement au Bénin. Acquis et Perspectives, 3–7 December 1990, Cotonou. Direction de la Recherche Agronomique (DRA) and Recherche Appliquée en Milieu Réel (RAMR), Cotonou, pp. 32–40.

Russell, T., 1997. Pair-wise ranking made easy. In: PLA Notes No 28, Methodological Complementarity. International Institute for Environment and Development (IIED), London, pp. 25–26.

Singh B.B., O.L. Chambliss & B. Sharma, 1997. Recent advances in cowpea breeding. In: B.B. Singh, D.R. Mohan, K.E. Dashiell & L.E.N. Jackai (Eds), Advances in Cowpea Research. International Institute for Tropical Agriculture (IITA) and Japanese International Research Center for Agricultural Sciences (JIRCAS), Ibadan, pp. 31–49.

Terauchi, R., V.A. Chikaleke, G. Thottappilly & S.K. Hahn, 1992. Origin and phylogeny of Guinea yam as revealed by RFLP analysis of chloroplast DNA and nuclear ribosomal DNA. *Theoretical and Applied Genetics* 83: 743–751.

Tostain, S., F.K. Okry, N.M. Baco, R.L. Mongbo, C. Agbangla & O. Daïnou, 2003. La domestication des ignames *Dioscorea abyssinica* dans les sous-préfectures de Sinendé et de Bantè au Bénin (Afrique de l'Ouest). *Annales des Sciences Agronomiques du Bénin* 4: 33–54.

Wood, D. & J.M. Lenné, 1997. The conservation of agrobiodiversity on-farm: questioning the emerging paradigm. *Biodiversity and Conservation* 6: 109–129.

Worede, M., 1997. Ethiopian *in situ* conservation. In: N. Maxted, B.V. Ford-Lloyd & J.G. Hawkes (Eds), Plant Genetic Conservation. The In Situ Approach. Chapman & Hall, London, pp. 290–301.

Zoundjihékpon, J., 1993. Biologie de la reproduction et génétique des ignames cultivées de l'Afrique de l'Ouest, *Dioscorea cayenensis-rotundata*. PhD thesis National University of Ivory Coast, Abidjan, 306 pp.