Complementarity between Geographical and Social Patterns in the Preservation of Yam (*Dioscorea* sp.) Diversity in Northern Benin[1]

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COMPLEMENTARITY BETWEEN GEOGRAPHICAL AND SOCIAL PATTERNS IN THE PRESERVATION OF YAM (*DIOSCOREA* SP.) DIVERSITY IN NORTHERN BENIN. This study was undertaken to contribute to the sustainable management of yam (*Dioscorea* sp.) diversity in Benin. We surveyed 220 farms from eight different villages in the north part of Benin. We hypothesized that the richness of yam cultivars is more related to farmers' ethnic group than to their geographical location. Cultivar diversity may differ from one ethnic group to another within a given area, but remains constant for a given ethnic group independent of its geographical location. This study identified 182 yam cultivars in the region; however, only a few farmers on a very small scale marginally produce more than 50% of that total richness. Cultivation practices as well as historical and socio–cultural determinants played important roles in the creation and maintenance of yam diversity within each ethnic group. The Bariba and the Gando ethnic groups, having developed yam cultivation since time immemorial, still hold the most diverse collection of yam varieties. The access of farmers to main roads and the availability of arable land in a given village greatly influenced the overall yam diversity in the region. This study highlighted the need to combine social determinants and geographical patterns in the conservation of agricultural diversity in Benin.

Key Words: Agrobiodiversity, Benin, cultivars, ethnic group, food plants, yam.

Since the adoption of the Convention on Biodiversity in 1992, there is a general agreement on the importance of biodiversity; in particular, the diversity of cultivated plants to fill the needs of the world population. Agro–biodiversity erosion, which occurs each year (FAO 1998), compromises the future. In Benin, where poverty affects 31% of the rural population (Fourmann 2002), agro—biodiversity faces high risks, especially in the north. Various factors contribute to such a dramatic situation. Among those that concern farmers as they define cultivation strategies include the so–called "dictatorship" of cash crops, the migratory flows between regions and countries, and the market for crops.

Yam cultivation accounts for 8% of the total cultivated land in Benin. Benin's yam production corresponds to 4% of the total yam production in Africa, and represents the fourth largest production in the continent behind Nigeria, Ivory Coast, and Ghana. Unfortunately, the intra–specific diversity of yam cultivars is threatened by the introduction of new cultivars that perform better agronomically and commercially. One example is the florido yam from Puerto Rico. Within a few years, the introduction of the florido yam in Ivory Coast resulted in the abandonment of traditional cultivars by many villagers (Hamon et al. 1995).

Domestication is assumed to be the traditional form of cultivar creation, but this process is carried out currently by few farmers in Benin (Baco et al. 2004). Natural ecosystems, which are the source of the raw material for yam domestication,

[1] Submitted 6 December 2006; accepted 25 August 2007.

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are disappearing due to shifting cultivation and demographic pressure.

Conservation strategies that focus only on *ex situ* conservation present some weaknesses (Hamilton 1994; Miller et al. 1995) and *in situ* conservation policies should have a complementary process. However, local inhabitants are not very involved in local conservation strategies despite the paramount role they play in production and biodiversity conservation (Brush 1992). This low–level involvement of farmers in conservation strategies probably results from an insufficient understanding of how these strategies can manage the diversity of cultivated plants.

We assessed the geographical and social determinants of yams' varietal diversity in the north of Benin. Our first hypothesis was that the geographical isolation of a village, or on the contrary, its proximity to transportation facilities, may influence yam diversity. The second hypothesis was that migratory flows, and therefore the mixing of cultures within the villages, favor the level of diversity in the village. Land availability is probably the third factor that affects yam diversity in the study areas. The fourth hypothesis was that geographical proximity of villages favors exchanges and sharing of yam cultivars. We also highlighted the importance of some ethnic groups whose practices better promote biological diversity in the region.

Materials and Methods

Study Area, Selection of Study Villages, and Units of Observation

The study was undertaken in the northern part of Benin where agriculture constitutes the main source of income. Northern Benin is a cosmopolitan zone where the majority of, if not all, ethnic groups dedicate most of their time to yam cultivation. This region of Benin encompasses arid and semi–arid regions (9°–11° N) with Sudanian to Sahelo–Sudanian climate. The annual average rainfall is 900–1,100 millimeters (mm), with the dry season extending from November to March and the rainy season from April to October.

Benin encompasses about 50 different ethnic groups (Floquet and Van den Akker 2000; SIL International 2001). An ethnic group is defined as an element of social typology, which includes the way people in a given community communicate among themselves as well as how that community's traditions, history, and food habits contribute to the establishment of basic knowledge required for the management of agrobiodiversity (Perales et al. 2005).

In the study region, the Baribas constituted the most important ethnic group and differed from others mainly by their social position and their activities, which consisted of handwork, eventually agriculture, but never animal husbandry. In the social hierarchy, Bariba formed the higher caste (Lombard 1965).

Lombard (1960) defined the Peules as ". . . a group of higher statute but with no enviable fate. Their faith (Moslem) and their richness (cattle) confer them no prestige to the eyes of Bariba princes who used to devaluate all that was not warlike." Originally, the Peules were nomadic cattle breeders; currently, they are becoming agro–cattle breeders because of the constraints they face in transhumance.

In the ethno–ethnic differentiation of northern Benin, members of the Gando group fall into the lower level of the society (Bierschenk 1995). They were slaves and prisoners who used to work for Bariba princes and eventually for the Peule pastors. The majority of them were either prisoners of war or Bariba natives who had been abandoned in their childhood subsequent to a birth considered "malefic" or "abnormal." Even now, such traditional beliefs remain in people minds (Hardung 1997).

Berba and Lokpa are two other ethnic groups that form the principal actors of migratory dynamics. Members of these groups are motivated to leave their homes in Atacora because of its soil degradation in search of the virgin and fertile lands in Borgou. The Nagot ethnic group resides in the transition zone between the north and central parts of Benin. This zone is also a receptacle of strong dynamic migration. Nagot people are considered to have originated from Yoruba people of Nigeria with whom they share indeed many similarities.

We surveyed 220 randomly selected households distributed in eight villages (Table 1). The villages were selected taking into account their ethnic diversity, accessibility by road (landlocked or not), and the presence of a local market (Fig. 1).

Data Collection

We used the term "cultivar" to refer to a set of plants whose characteristics are sufficiently similar to be recognized by the farmers as a category and designated by a proper name (Pinton and Emperaire 2001). Each cultivar represents a

TABLE 1. CHARACTERISTICS OF THE VILLAGES AND SELECTION OF THE STUDY UNITS.

Villages	Market	Road	Land availability	Number of ethnic groups	Ethnic groups						%
					Bariba	Berba	Gando	Lokpa	Nagot	Peule	
Agbassa	No	ST	NA	3		6			18	10	16
Goro	Yes	SR	A	4	17	15			3	16	23
Gorobani	No	ST	A	4	7	5	17				13
Kinnou Kpanou	No	PT	A	4	19	3			9	4	16
Kparo	No	ST	A	1	14						6
Sèkèrè	Yes	SR	A	2	12						5
Wari	Yes	SR	A	2	3		12				7
Yébessi	Yes	PR	NA	1				30			14
		%			32	13	13	14	14	14	100

named category (Caillon and al. 2006), which is the physical object through which the farmers manipulate biodiversity. In this sense, the local perception of biodiversity, which is expressed through the local names, remains a good starting point for studying biodiversity management (Jarvis and al. 2004).

Different authors have addressed the genetic nature of those "named categories," particularly in the case of plants that regenerate through vegetative organs, such as cassava (Emperaire and al. 1998) or taro (Caillon and al. 2006). In the case of yams in Benin, Scarcelli (2005) addressed the same question on similar samples as ours and showed that one yam cultivar is often made of two to four clones and, in 80% of the cases, the farmer's categories correspond to the biologist's ones.

For each farm, the information collected concern yam cultivars, the number of mounds per cultivar, the exchange of cultivars between farmers, the motivation for producing cultivars, the origins and reasons of migration, and the attended markets. In order to avoid skews between the name given and the biological material concerned, we selected only households that knew the cultivars. Moreover, various discussions with elderly persons in the villages and information from the study by Dumont et al. (2005) helped manage synonymies. The constitution of a database made it possible to develop comparative statistics.

DATA ANALYSES

Accumulation Curves and Prediction at the Level of the Population

Accumulation curves give the cumulated number of observed cultivars depending on the number of observations (i.e., enquiries among the cultivators). The classical curves depend on the order of the inquiries and allow neither the estimation of the cultivar richness at the population level nor the comparison of different samples. We used a statistical device known as EstimateS (Colwell 2004; Colwell et al. 2004) to establish the accumulation curve of Mao Tau (the expected richness function that does not depend on the order of the observations; rather, it uses a randomization procedure that allows the determination of standard error for the estimates), and the Chao 2 (μ = mean, σ = standard deviation) estimator of the richness at population level (including species not present in any sample), which is based on the abundance. For each sample size, a mean estimated richness and a standard error were determined. Such data enabled us to undertake the within—group—differences test.

Similarity Index

The Chao–Sorensen similarity index (Chao et al. 2005) between groups (villages or ethnic groups) has been calculated with EstimateS based on cultivar densities.

Results

DISTRIBUTION OF YAM DIVERSITY

There was a large dispersion of yam diversity within the study villages. Only 6 (Ahimon, Baniwouré, Dani, Kokouma, Kpakara, Kpouna) of the 182 cultivars found were cultivated in all eight villages, and 95 cultivars (almost 50%) were cultivated in only one village. The villages Sekere, Kparo, and Gorobani cultivated approximately 50 cultivars while Goro and Kinnou Kpanou cultivated around 40 cultivars (Table 2). However, there was no significant difference between both groups ($t = 0.7$, $df = 66$). With an average of 30 cultivars,

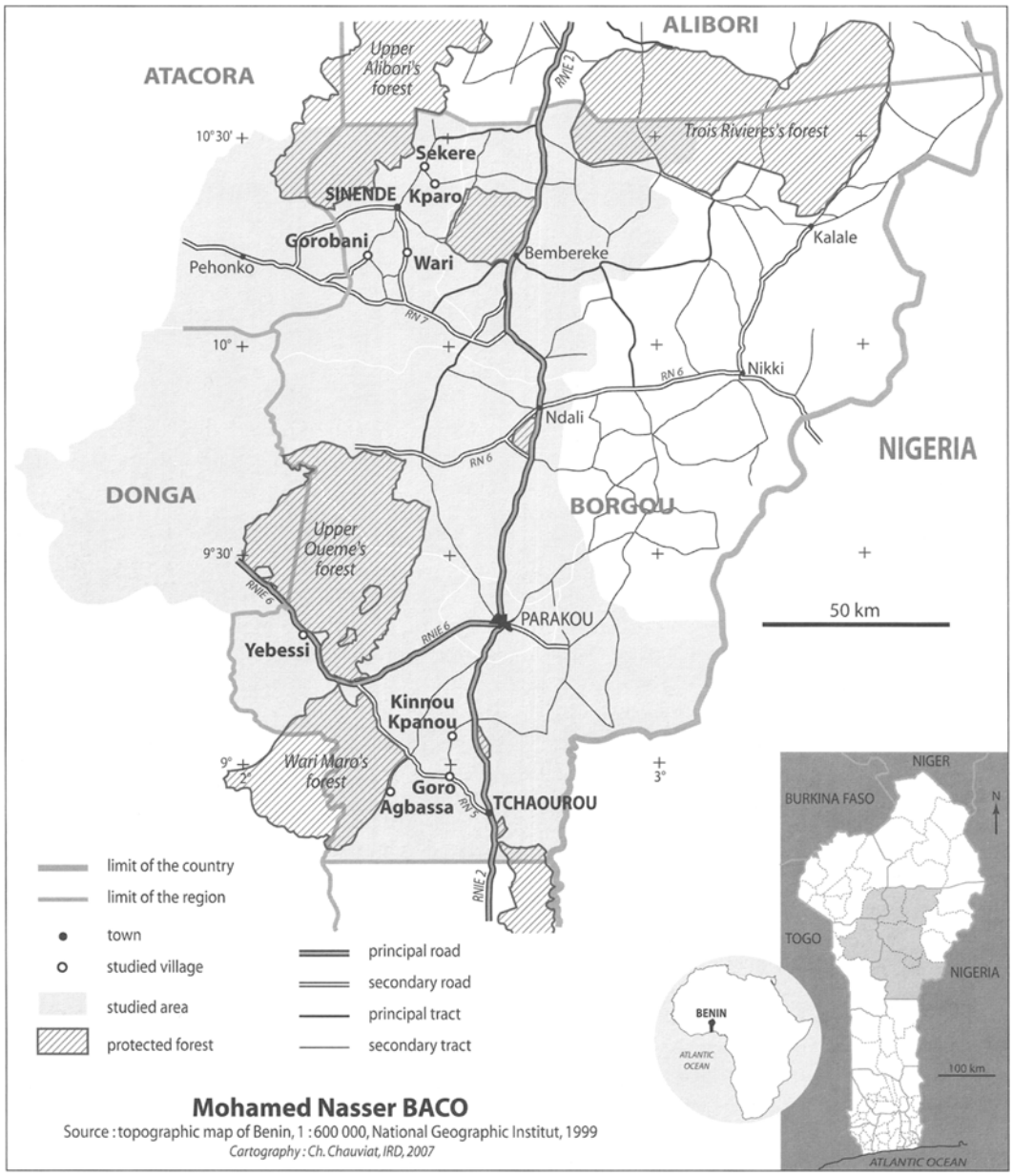

Fig. 1. The study area indicating the geographical position of the villages. **PT** = Principal track, not very practicable during the rainy season; **ST** = Secondary track, not practicable during the rainy season; **SR** = Secondary road (not bituminized); **PR** = Principal road (bituminized); **Yes** = Presence of market in the village; **Not** = No market in the village; **A** = Land available, can accommodate migrants, **NA** = land not available, cannot accommodate new migrants.

Yébessi, Wari, and Agbassa have the lowest diversities. A comparison of the pairs Wari–Yébessi and Wari–Agbassa (respectively $t = 3.6$ and 3.1 $df = 47$, $p < 0.01$) showed that Wari was significantly different from both Yébessi and Agbassa.

Similarity between Villages

There is a high diversity of cultivars within the sampled villages. The similarity index between villages (Table 3) shows that Yébessi clearly deviates from others by values under 0.25. The vil-

TABLE 2. OBSERVED NUMBER OF CULTIVARS IN EACH VILLAGE.

Parameters	Agbassa	Goro	Gorobani	Kinnou Kpanou	Kparo	Sèkèrè	Wari	Yébessi
Mao μ	32.84	38.6	46.02	34.99	54.33	52	31.05	33.57
Tau σ	2.85	3.22	3.28	3.13	2.5	4.49	2.39	3.06

lages that shared the highest number of cultivars were Goro–Kinnou Kpanou, Gorobani–Kparo, and Kparo–Sékéré.

DISTRIBUTION WITHIN THE ETHNIC GROUPS

Depending on sample size, the accumulation curves vary rapidly and we can assume that the samples of 30 farmers are large enough to reveal differences within ethnic groups (Figure 2). The Berba ethnic group cultivated significantly fewer cultivars than Lokpa ($t=2.16$, $df=58$, $p<0.05$). The Lokpa cultivated significantly fewer cultivars than the Nagot people (for Lokpa×Nagot, $t=6.47$, $df=59$, $p<0.01$). The groups Bariba, Nagot, and Gando cultivated the highest number of cultivars; however, within this group, the Bariba people hold the first position (for Bariba×Nagot, $t=7.29$, $df=104$, $p<0.01$).

The Lokpa and Berba cultivated fewer cultivars than the other groups (Table 4). But there is a significant difference (95%) between these two groups.

Bariba, Gando, and Nagot had the highest number of cultivars, but for the same sample size, the average number of cultivars differed significantly between Bariba and Nagot. There was no significant difference between Bariba and Gando and no difference in number of cultivars was found between Nagot and Gando.

The diversity estimator revealed that the Peules have up to 93 cultivars, with a very strong intra-group variability as revealed by the strong value of the standard deviation (42.32). The large standard deviation as well as the accumulation curve did not allow us to draw reliable conclusions.

Bariba shared a large part of their collection with all the other groups except with the Ḷokpa (Table 5). The Lokpa were a particular ethnic group, since the similarity index between this group and the others remained lower than 0.25. Similarity indices between Berba–Peule and Peule–Nagot are high, suggesting great similarities of the cultivars pools held by these two ethnics groups.

Discussion

GEOGRAPHICAL DETERMINING FACTORS OF THE DIVERSITY

Our first hypothesis was that the geographical isolation of a village, or on the contrary, its proximity to transportation facilities, may influence yam diversity. Gorobani, a village that is far from the roads, showed high yam diversity while Yébessi and Wari villages, which border the main and secondary roads, respectively, had the lowest number of cultivars. As the road enhances the ability to get crops to market, diversity tends to be reduced to the products that are appreciated by the buyers in the markets. This is consistent with the results found elsewhere (e.g., Eyzaguire et al. 2000). Bellon (2001) suggested a direct link between the loss of diversity and the evolution of market demand. In Benin, increasing market demand of the yam on the national scale and increasing exportation to Nigeria, Niger, and Burkina Faso were observed. Such practices date back to the independence of the country in 1960, when politicians favored the relocation of local inhabitants closer to the main roads. In this context,

TABLE 3. SIMILARITY INDEX BETWEEN VILLAGES (CHAO-SORENSEN).

Villages	Agbassa	Goro	Gorobani	Kinnou	Kparo	Sèkèrè	Wari
Goro	0.808						
Gorobani	0.579	0.567					
Kinnou Kpanou	0.867	0.914	0.667				
Kparo	0.533	0.559	0.914	0.654			
Sèkèrè	0.479	0.476	0.848	0.483	0.846		
Wari	0.539	0.539	0.834	0.595	0.898	0.840	
Yébessi	0.192	0.205	0.158	0.185	0.152	0.153	0.167

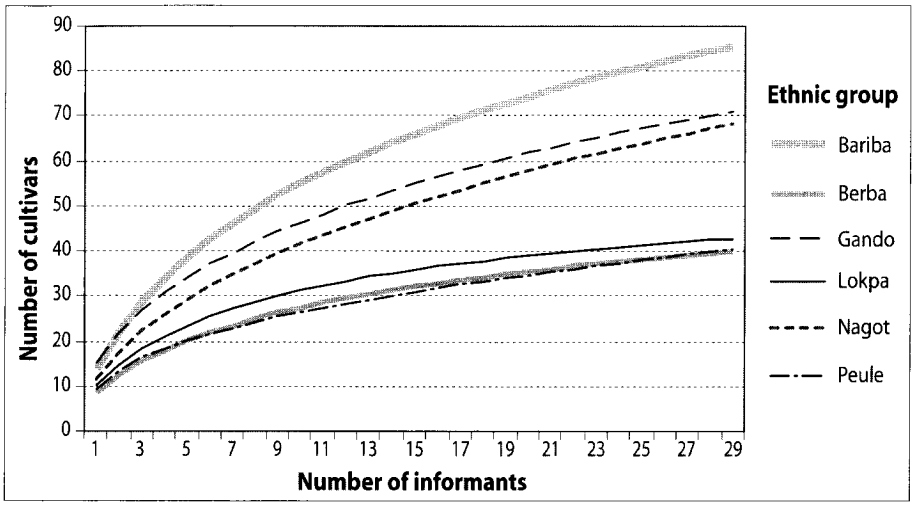

Fig. 2. Accumulation curves of the yams cultivars richness per ethnic group.

various villages emerged along main roads during 1960–1963, among them Yébessi and Wari.

Our second hypothesis was that migratory flows, and therefore the mixing of cultures within the villages, enhance the level of diversity in the village. Degradation of soil fertility and ecosystems is a great concern in Benin (Floquet and Mongbo 1998). Farmers of the northwestern regions of Benin abandoned their lands and move towards other regions or to Nigeria. However, the current economic crisis of Nigeria and the depreciation of its currency contribute to increase inter–regional flows in Benin (Bruntrup 1997) and the mixing of cultures in villages near the borders between both countries. Goro, Gorobani, and Kinnou Kpanou, which have high levels of yam diversity, were also the villages with high levels of cultural diversity.

The land availability is probably the third factor that affects yam diversity in the study areas. The low yam diversity in the village of Agbassa could be explained by two factors. First, the road enhanced the market–oriented production that may have led to a reduction in the diversity of cultivars; the farmers may have selected to grow the most productive cultivar. Second, the village dwells on the border of the Wari–Maro protected forest and cannot expand its cultivated area. Therefore, the village cannot welcome large number of migrants and the cultural diversity remains low. The same reason explains the low yam diversity in the village of Yébessi, which is located close to the Ouémé Superieur forest reserve.

Our fourth hypothesis was that geographical proximity of villages favors exchanging and sharing of yam cultivars. Neighboring villages such as Goro–Kinnou Kapnou or Kparo–Sékéré showed higher similarity indices than the other groups of villages. Short distances between villages–less than 15 kilometers (km)–favored the exchange of cultivars. When the distance between villages was more than 100 km (e.g., Yébessi–Gorobani, Goro–Kparo), the cultivars exchanging process was reduced and the similarity index also was found to be low.

Cultural Determining Factors of the Diversity

An ethnic group is based on the way in which its members communicate. It is also identified by

Table 4. Estimated number of cultivars hold by each ethnic group on a sample of 29 households (Chao 2).

Parameters	Bariba	Berba	Gando	Lokpa	Nagot	Peule
Chao 2 μ	117.28	43.61	97.17	47.12	99.48	92.79
σ	13.3	4.67	14.71	4.99	16.29	42.32

TABLE 5. SIMILARITY INDEX BETWEEN THE ETHNIC GROUPS (CHAO-SORENSEN).

Ethnics groups	Bariba	Berba	Gando	Lokpa	Nagot
Berba	0.809				
Gando	0.778	0.599			
Lokpa	0.234	0.190	0.105		
Nagot	0.846	0.768	0.556	0.243	
Peule	0.858	0.836	0.626	0.122	0.861

its traditions, history, and eating habits, contributing to the knowledge and know-how on which practices of biodiversity management are based (Perales and al. 2005). Though they were living in similar environmental conditions, the ethnic groups observed in northern Benin cultivated specific cultivars. In Yébessi village, the Lokpa constituted the main ethnic group. They preferred and cultivated the biggest yam tubers such as Hê-aballo, Witanam, Samassi-hê. The Nagot ethnic group living in Kinnou Kpanou village favored Kokoro, a yam variety with small tubers adapted to produce easily marketable dried yams. The Bariba and Gando grew medium-sized tubers, such as Moroko, Ahimon, Dani, and Kpouna.

Bariba and Gando ethnic groups cultivated a higher number of yam cultivars than the other groups. This may be explained by their common history and cultural heritage, based on yam cultivation for centuries. The Gando were enslaved by the Bariba. Most of the Gando were war captives and some of them were born Bariba but abandoned when young because their birth was judged sinister or abnormal (Lombard 1960). The social death that proceeds from enslavement leads to the lack of cultural references and to the mimicking of the master (Meillassoux 1989). This could explain the highest level of similarity of yam cultivars between the Bariba and the Gando.

Bariba and Nagot also shared numerous cultivars. This could be explained by their common origin in Nigeria from where they emigrated to found feudal kingdoms in middle and north Benin (Lombard 1965). The abolition of slavery introduced by the colonial power in 1896 has weakened those two slave kingdoms (Alber 1997) and the mistrust they had towards each other slowly disappeared. Today those two groups maintain friendly relationships even though each of them still claims its cast dominance in the past.

This secular relationship has never existed between Nagot and Gando. This could explain the lack of similarity between their landrace portfolios, even though each of them is independently linked with Bariba.

Lokpa and Berba cultivate fewer cultivars than the other groups. This could be explained by the fact they are recent immigrants in the region. Lokpa moved from their villages 40 years ago following political measures and they still move because of demographic pressure on the land. Berba are abandoning their villages in the northwest mountains because of the lack of land and because their land has low soil fertility; they are trying to survive in their new settlements marketing their labor in agriculture. They rarely migrate with their cultivars and they content themselves with the cultivars they could find in their new territories.

The lack of unique cultivars may reveal a singular behavior in the Peule group, widely known as cattle breeders, which may be linked to the absence of a cultivation tradition. In Benin, Peule are seen as marginal peoples, tied to their tradition, and having learned for centuries to come to an agreement with the hegemonic groups on the land to which they continuously immigrate (Bierschenk 1995). Their unsettled way of life in the bush would slow their development. But today, one can observe among this group a growing interest in agriculture; however, if they are turning into farmers in Benin, they still differ from the other groups who have developed for long decades a sound know-how in yam cultivation.

Conclusions and Recommendations

There was a high level of diversity of yam varieties in the study region, with a total of 182 cultivars identified. Among them, only six are widely cultivated and commonly observed in the eight villages of the present study. The cultivars that are produced the most are those that are easily pounded up, stored, propagated, and taken to market.

The varietal diversity of yams in the north of Benin is a result of cultural practices as well as social and economic factors. In spite of the similar environmental conditions, the ethnic groups cultivate different cultivars and use farming techniques in connection with their traditions. Lokpa and Berba prefer the large tubers, Bariba and Gando choose the cultivars of average size, and Nagot prefer the cultivars with small tubers.

One should be aware that yam diversity results from farming practices as well as from cultural,

social, and economic dynamics. Ethnic groups manage their diversity in different ways, depending on their history. If the Bariba and the Gando, whose civilization is linked to yam cultivation since time immemorial, still hold the most diverse collections of yam varieties, the recent involvement of the Peule in agriculture opens new perspectives.

From a methodological point of view, the main challenge consists in identifying the territories where social processes have resulted in the highest level of diversity management. When taking into account both local and regional scales, one must bear in mind that the cultivars can range far from their home base as they follow migratory flows and as they are used for gifts and reciprocal gifts among the traditional societies within a regional or even a trans—national area. Exchanging cultivars among cultures in countries such as Nigeria, Ivory Coast, Ghana, and Togo contribute to the spatial dynamic of yam diversity.

Acknowledgements

We are much indebted to IRD (Institut de Recherche pour le Développement), INRAB (Institut National de Recherche Agricoles du Bénin), and Bioversity International for their financial support. A special thanks is due to Dr. Humphrey Bowden, Nourou S. Yorou (University of Munich), and Orou G. Gaoue (University of Hawai'i) for their assistance with the linguistic checking of the manuscript.

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