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Full Length Research Paper

Chili (*Capsicum annuum* L.) in southern Benin: production constraints, varietal diversity, preference criteria and participatory evaluation

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Abstract

Chili (*Capsicum annuum* L.) is an economically important spice widely cultivated in Benin. In order to document its diversity and identify the best performing varieties which could meet producers' and consumers' needs, surveys were conducted in thirty-one villages randomly selected in southern Benin. Ten production constraints of agronomic nature were identified among which the most important were attacks of insects on fruits, viral infection, early fall of the plant's organs (leaves, flowers, fruits) and anthracnose. The number of varieties identified varies from 3 to 8 (5 on average) per village and from 1 to 7 (2 on average) per household. The distribution and extent analysis revealed that out of 5 varieties on average cultivated per village, only two are cultivated by many households and on large areas. The average rate of varietal diversity loss is 23.53% per village. Farmers' varietal preference criteria (17 in total) identified and prioritized were essentially agronomical characters (86.89% of the responses) and the most important were related to the post-harvest storage aptitude of the fruits, the productivity and the seed germination capacity. A participatory evaluation of the varieties has led to identification of the best performing ones per trait of economic importance. Throughout surveyed sites, 197 accessions of farmer-named landraces were collected and their agromorphological characterisation is recommended for clarification of synonymies and breeding purposes.

Keywords: Benin, chili, constraints, diversity, evaluation, preference criteria.

INTRODUCTION

Chili (*Capsicum annuum* L.) is a spice, a fruit vegetable widely cultivated in the world and which importance in human food is capital (Dias et al. 2013; Wahyuni et al. 2013). Originated from South and Central America, chili, of the genus *Capsicum,* has more than 25 species of which only five (*C. annuum* L., *C. chinense* Jacq., *C. frutescens* L , *C. baccatum* L. and *C. pubescens* Keep.) are domesticated and cultivated (Bosland and Botava, 2000; Costa et al., 2009). Due to the existence of many difficult to identify intermediary forms resulting from natural interspecific crosses, the former three species (*C. annuum* L., *C. chinense* Jacq., *C. frutescens* L.) are now treated as one species (*C. annuum* L.) with four cultivars groups (Nsabiyera et al. 2013) that are: *chinense* group (West Indies chili), *frutescens* group (bird chili), *annuum* group (hot chili) and sweet pepper group.

Throughout the world, chili is consumed fresh, dried or in powder (El-Ghoraba et al. 2013). It is rich in proteins, lipids, carbohydrates, fibres, mineral salts (Ca, P, Fe) and in vitamins A, D3, E, C, K, B2 and B12 (El-Ghoraba et al. 2013). The fruits are an excellent source of health-related phytochemical compounds, such as ascorbic acid (vitamin C), carotenoids (provitamin A), tocopherols (vitamin E), flavonoids, and capsaicinoids that are very important in preventing chronic diseases such as cancer, asthma, coughs, sore throats, toothache, diabetes and cardiovascular diseases (El-Ghoraba et al. 2013; Wahyuni et al. 2013). Moreover, the consumption of fresh fruits facilitates starchy food digestion (Bhattacharya et al. 2010). Chili has antioxidant, anti-mutagenesis, hypocholesterolemic and immunosuppressive properties (El-Ghoraba et al. 2013) and also inhibits bacterial growth and platelet agglomeration (Wahyuni et al. 2013). At global level, chili is one of the spices that generate huge revenues for producers and therefore contributes to poverty alleviation and improvement of women's social status (Karungi et al. 2013). Despite its economic, food and medicinal importance, chili remains in many countries a neglected crop that is rarely of national priority in terms of agricultural development (FAO, 2010). Therefore, its cultivation is still traditional and is facing many biotic (Pests, diseases), and abiotic (drought, high soil moisture, salinity, soil poverty, etc.) stresses that cause severe yield losses (Khan et al. 2009; Segnou et al. 2013; Zhani et al. 2013).

In developing countries and particularly in Sub-Saharan Africa, mainly insecticides are used to control insect pests known as the most important chili enemies (Segnou et al. 2013). However, insecticides are very costly for the majority of resource poor small-scale producers (Segnou et al. 2013) and their utilisation has negative impacts on human health and on the environment (Devine and Furlong, 2007). In that context and for many other factors such as drought, salinity and high moisture content, biological control through use of resistant or adapted varieties is recommended (Houimli et al. 2008; Truong et al. 2013). Such varieties can be developed or simply searched for within the existing diversity. In both cases, a good knowledge of the existing varietal diversity and of the agronomic performances of varieties is necessary (Ajjapplavara 2009; Melendez et al. 2009; Nsabiyera et al. 2013; Dias et al. 2013). Moreover, better orientation of improvement programs also calls for mastering production constraints and farmers' varietal preference criteria (Dansi et al. 2010; Zhang et al. 2012).

In Benin, chili is the second market gardening crop after tomato (Assogba-Komlan et al. 2009). Its annual production is about 47.162 tonnes and has never evolved over the last 10 years (Assogba-Komlan et al. 2009). Moreover, except for research works on natural enemies conducted in different production zones and the few agronomic assessment trials conducted on certain varieties (Assogba-Komlan et al. 2009), no other significant study has been conducted on chili in Benin. Production constraints are not yet documented, varietal diversity as well as farmers' varietal preference criteria and their variation throughout agro-ecological and ethnic zones are still unknown, and the agronomic performances of the varieties are not documented anywhere to be exploited by scientific research and development. We present in this article the findings of an ethnobotanic investigation conducted on chili (frutescens, annuum and chinense groups) in southern Benin in order to:

- Identify and prioritize constraints related to chili production
- Examine existing varietal diversity and analyse the distribution and extent of the varieties
- Identify and prioritize farmers' varietal preference criteria
- Assess the agronomic performance of the varieties

MATERIAL AND METHODS

The study area and sites selection

The Republic of Benin is situated in West Africa and between the latitudes 6°100 N and 12°250 N and longitudes 0°450 E and 3°550 E (Akoègninou et al. 2006). It covers a total land area of 112,622 km^2 with a population estimated at about 7 million (Yabi and Afouda, 2012). The study was conducted in the southern part of the country consisted of six departments (Atlantique, Littoral, Mono, Couffo, Oueme, Plateau) inhabited by ten ethnic groups (Adja, Cotafon, Holly, Ouémègbé, Pédah, Saxwè, Tori, Watchi, Xwla, and Yoruba) (Yabi and Afouda, 2012). This region is a relatively humid agroecological zone with two rainy seasons and means annual rainfall vary from 1,100 to 1,400 mm/year (Yabi and Afouda, 2012). Mean annual temperatures range from 26°C to 28°C and vegetation types are semi-deciduous forests or woodland and savannah woodland (Akoègninou et al. 2006). In order to sufficiently cover the study area, surveyed villages (31 in total) were randomly selected throughout the different departments and ethnic areas. Surveyed villages are listed in Table 1 and their geographical locations are indicated in Figure 1.

Data collection

Data were collected during expeditions from the different sites through the application of participatory research appraisal tools and techniques, such as direct observation, group discussions, individual interviews, and

Table 1. Name, district and ethnic groups of the villages surveyed

N°s	Villages	District	ethnic groups
1	Adakplamè	Kétou	Mahi
2	Adjahonmè	Klouékanmè	Adja
3	Ahoyéyé	Pobè	Nagot
4	Atchonsa	Bonou	Ouémè
5	Atchoukpa	Avrankou	Goun
6	Avédjin	Toviklin	Adja
7	Azohouè-Kada	Allada	Aïzo
8	Badazouin	Bopa	Adja
9	Damè	Toffo	Aïzo
10	Damè-Wogon	Bonou	Ouémè
11	Danhoué	Houéyogbé	Sahouè
12	Dawé	Zè	Aïzo
13	Dékpo	Aplahoué	Adja
14	Dogo	Kétou	Nagot
15	Gangban	Adjohoun	Ouémè
16	Gbokoutou	Ifangni	Nagot
17	Hoki	Aplahoué	Adja
18	Houèdèmè-Adja	Lokossa	Cotafon
19	Ichagba-Holli	Pobè	Holli
20	Igbo-Edè	Pobè	Nagot
21	Ikpinlè	Adja-Ouèrè	Nagot
22	Illéchin	Kétou	Nagot
23	Koudo	Lokossa	Cotafon
24	Kpoba	Djakotomey	Adja
25	Savi	Ouidah	Fon
26	Sè	Toffo	Aïzo
27	Sèdjèdénou	Zè	Aïzo
28	Sokouhoué	Djakotomey	Adja
29	Tangbo-Djèvié	Zè	Aïzo
30	Voli	Aplahoué	Adja
31	Zounguè	Dangbo	Ouémè

field visits using a questionnaire following Adjatin et al. (2012), Kombo et al. (2012). In each village, interviews were conducted with the help of a local translator and groups surveyed were made of 20 to 40 chili producers of both sexes and of different ages identified and assembled with the assistance of the local farmers' associations and the chiefs of the village involved in the study to facilitate the organisation of the meetings and the collection of data according to Kombo et al. (2012).

According to the literature, several biotic and abiotic constraints are related to chili cultivation. If generally farmers have a very good knowledge of abiotic constraints it is not the case with biotic factors, especially diseases and pests (Assogba-Komlan et al. 2009). To help producers to easily identify the different types of chili pests and diseases, selected pictures were used. In each selected site information on the location (name of district, name of village, ethnic group, etc.) was first collected after a detailed presentation of the research objectives to the farmers. After this, farmers were asked to list (vernacular names) per category (abiotic and biotic) all the constraints related to chili production in their area. Using pictures, the specific types of pests and diseases listed were identified. The identified constraints were prioritized in groups by identifying and gradually eliminating the most severe constraint. In a first step, producers were asked to identify, among the constraints they have listed, the most critical one and for which an urgent solution must be found. The constraint thus identified is ranked first and is eliminated from the list. The same procedure was repeated until the last constraint was ranked and the results were given immediately to producers for approval.

Prior to the meeting, farmers were requested in advance to bring samples of the chili varieties they cultivate or knew about. For diversity analysis, farmers

Figure 1. Map of southern Benin showing the geographical localization of the surveyed sites

were asked to list (vernacular names) and display the different varieties of chili they grow in their village. Through discussions, detailed agronomic and culinary characteristics of the listed varieties were documented. The distribution and extent of the varieties were assessed using the Four Squares Analysis approach described by Dansi et al. (2010) and Kombo et al. (2012) and which help, at community level and on participatory way, to classify existing varieties into four groups (varieties cultivated by many households on large areas; varieties cultivated by many households on small areas; varieties cultivated by few households on large areas, and varieties cultivated by few households on small areas) taking into account the area (large or small) devoted to the variety and the number of households (few or many) cultivating it (Kombo et al. 2012). After this, the discussion moved to details of each variety with the objective of understanding the reasons for their status. Hence, reasons that justify the cultivation of each variety by many or few households and on large or small areas were documented.

Participatory evaluation of identified chili varieties was also carried out according to Gbaguidi et al. (2013) and based on an agronomic and technological evaluation form. Parameters considered were productivity, duration of the cycle, resistance to organs (leaves, flowers and fruits) fall, resistance to anthracnose and necrosis, resistance to insects, fruits conservation length, tolerance to salinity, adaptability to all types of soils, tolerance to high soil moisture content, fruits size, drought tolerance, relative seed germination rate, fruit aroma, resistance to viruses and easiness to grind the fruits. The two-level evaluation method described by Loko et al. (2013) was used. In this approach and for a given trait, a variety is scored (group of framers) 1 when it is performing and 0 when it is not.

Individual surveys were also conducted in 9 to 10 households randomly selected in each of the 31 villages surveyed using the transect method described by Adjatin et al. (2012). In each household, the interviewee was designated by mutual agreement by the host couple according to Gbaguidi et al. (2013). In total, 290 chili producing households represented by 105 women and 185 men producers were interviewed. Three types of data were collected per household. These were: socio-demographic data (Age, sex, cultivated area, and number of labour, size of household and education level), the varietal diversity kept by the household and farmers' varietal preference criteria. Preference criteria were identified using the comparison matrix method (Adoukonou-Sagbadja et al. 2006) and prioritized according to Kombo et al. (2012).

Data analysis

Data obtained were analysed using descriptive statistics (average, percentage, etc.) and the results were presented in the form of tables or figures. At the level of the study area, the constraints were prioritized based on the means of the following three parameters:

- The total number of villages (TNV) in which the constraint is cited
- The number of villages in which the constraint was classified among the principal constraints (PCO) i.e. among the first five
- The number of villages where the constraint is the major one or ranked first (MAC).

For these three parameters, the higher the number is, the more important is the constraint.

The importance of a constraint (IMC) was determined by the formula IMC = (TNV + PCO + MAC)/3**.**

The rate of variety loss (RVL) at the village level was determined, according to Kombo et al. (2012), using the formula RVL = (n - k)/N x 100 where n is the number of endangered varieties (cultivated by few households and small areas); k is the number of varieties newly introduced; N is the total number of varieties identified in the village. Relationships between socio-demographic parameters (Age, sex, cultivated acreage, number of labour, household size, and education level) of the households and the varietal diversity it manages were examined through Pearson correlation analysis using Minitab14 software (Minitab Inc., State College, PA, USA). Farmers' varietal preference criteria are prioritized based on the percentages of responses. To study chili varietal diversity in terms of agronomic and technological performances, a dendrogram was constructed using UPGMA (Unweighted Pair-Group Method with Arithmetic Average) clustering method and NTSYS-pc 2.2 (Numerical Taxonomy and Statistical Analysis) software (Rohlf, 2000) by considering identified chili varieties as individuals and evaluation parameters as variables according to Kombo et al. (2012).

RESULTS AND DISCUSSION

Chili production constraints in southern Benin

Eleven chili production constraints of both biotic and abiotic nature were identified and prioritised in the study zone (Table 2). Among these, the most important are leaves, flowers and fruits attack by insect pests, viral diseases, organ fall (leaves, flowers, fruits) of the plant, damping-off and anthracnose. These results are similar to those reported by Park et al. (2007) and Krishnareddy et al. (2008). The fact that attacks by insects appear as the most severe constraint is not surprising. In chili, insects are among pests, those that cause the most severe damages that can reach sometimes 100% loss (Messiaen et al., 1991). Impacts of viral diseases and anthracnose on chili production (yield losses reaching up to 90%) are also nowadays well documented worldwide (Ristaino and Johnson, 1999; Grube et al., 2000). According to Black et al. (2010) fall of plants' organs is often caused by a lack or an excess of moisture of soil but can be also caused by other diseases which attack organs of the plants (bacterial spot, powdery mildew, bacterial wilt, verticillium wilt). Like anthracnose, damping-off, root rot and collar rot are caused by attacks of pathogenic fungi that often provoke enormous yield loss (Ristaino and Johnson, 1999; Alegbejo et al., 2006). Besides biotic constraints, producers have also mentioned abiotic constraints such as soil poverty, drought, excess of rain and salinity. According to Bosland and Bottava (2000) water shortage and salinity lead to yield decrease by more than 50%. The study revealed that producers have good understanding of the constraints related to chili cultivation in Benin. All the identified constraints can be overcome by using tolerant or adapted varieties. Like in cowpea (Gbaguidi et al. 2013), yam (Loko et al. 2013) and cassava (Kombo et al. 2012), such varieties may exist (maybe in insufficient number for some agronomic characters) in Benin traditional agriculture and must be identified for the benefit of producers. Contrary to cowpea (Gbaguidi et al., 2013) producers did not mention economic constraints and more specifically lack of final market. Therefore, a potential market exists and efforts must be made to find solutions to the constraints in order to increase chili production in southern Benin.

Folk nomenclature and varietal diversity

In southern Benin, chili is known under various generic

Table 2. Chili production constraints and their importance in southern Benin

Constraints	Importance	Ranking
Attack of insect pests on leaves, flowers and fruits	20,60	1
Viruses	15.93	2
Fall of plants' organs (leaves, flowers and fruits)	13,80	3
Damping-off	10.31	4
Anthracnose (Ripe rot, Shoot necrosis and leaf spots)	10.25	5
Post-harvest storage difficulties of fruits	7.70	6
Susceptibility of many varieties to poor soils	6.76	7
Susceptibility of many varieties to drought	6.25	8
Susceptibility of many varieties to salinity	3.94	9
Root rot and collar rot	2.52	10
Inadaptability of varieties to excess of rain	1.94	11

b) Plant of variety Adollogbo (group Annuum)

a) Plant of variety Gbohoungodoui (group Chinense)

Figure 2. Plants of *Capsicum annuum* (groups Annuum and Chinense) bearing fruits

Figure 3. Fruits of selected varieties showing morphological variability between and within chili groups in Benin. At the top, varieties of the group "Chinense"; at the bottom variety of the group "Frutescens" and at the middle varieties of the group "Annuum"

appellations: Ata (Nagot and Holli), Yébéssé (Mina), Takin (Aïzo, Cotafon, Fon, Goun, Mahi, Ouémè, Sahouè) and Vavo (Adja, Cotafon, Fon, Goun, Sahouè). Several chili varieties exist and are classified, according to producers, into three classes: long chili class called Takingaga in fon and Adôllôgbô in Adja; round chili class named Gbatakin (in fon), Gbôwoungodoui in Adja; and the very hot small chili class known under the name of Danhomètakin (Fon). These three classes (Figure 2; Figure 3) correspond exactly to the three taxonomic groups (*annuum, chinense* and *frutescens*) of chili. This result shows that producers have good knowledge of their plant material and therefore their knowledge can be capitalised by taxonomists and plant breeders as it was recommended by Dansi et al. (2010) for fonio (hungry rice), Kombo et al. (2012) for cassava and Gbaguidi et al. (2013) for cowpea.

The three types of chili, *Gbatakin* (*chinense*), Danhomètakin (*frutescens*) and Takingaga (*annuum*) were widespread and were found in all the 31 villages surveyed. *Gbatakin* is very appreciated by consumers. In the kitchen, its round fruit can be broken by just pressing on it between two fingers ("Gba" and "takin" in Fon mean respectively "break" and "chili") and thrown in any sauce without grinding it in order to keep low the intensity of the burning taste it will give to the sauce. Moreover, while fresh and green, Gbatakin has a much appreciated natural flavour. Takingaga is very adapted to drying and processing into powder. Its post-harvest storage for domestic use or commercial purpose (selling at high price during the dry seasons) is relatively very easy. Danhomètakin is not very common in the villages and this can be explained by its extremely burning taste (disliked) and very low yield making its production economically not profitable.

Producers mentioned the existence within each class of chili of many varieties they name based on several criteria including the size and the shape of the fruits, the origin of the variety, the specific use and the taste (degree of burning). At total 36 vernacular names were recorded. Each village seems to have its series of names. These were variable across both villages and ethnic areas. In local nomenclature such variations of vernacular names are common and were already reported in many crops including cassava (Kombo et al., 2012), acha (Dansi et al. 2010), sorghum (Mekbib, 2007), cowpea (Gbaguidi et al. 2013), and traditional leafy vegetables (Adjatin et al. 2012).

Subject to synonymy, 36 varieties of chili were identified in the 31 explored villages. Of these, 14 are from the *frutescens* group (small chili), 12 from the *annuum* group (long chili) and 10 from the *chinense* group (round chili); 34 are local varieties, one (Tataché) is introduced from Nigeria and another one (Carder) is introduced through development projects. The number of identified varieties varies from 3 to 8 (5 on average) per village. The greatest varietal diversity (8 varieties) was observed in the villages Hoki, Voli and Avédjin in the Couffo department (table 3) and the smallest diversity (3 varieties) is noted in the villages Atchoukpa and Zounguè in Ouémé department. Hoki, Voli and Avédjin being close to Togo, their richness in varieties may be explained by former introductions from Togo. Zounguè and Atchoukpa located in Ouémé valley known as the first chili producing zone in Benin (Assogba-Komlan et al. 2009) should normally exhibit an important varietal diversity. According to the producers interviewed, the low diversity observed in these villages could be due to the concentration of production on a small number of high yielding and economically profitable varieties. The distribution and analysis (Table 3) revealed a similar situation in all explored villages with only 2 varieties on average out of 5 per village cultivated by many households and on large areas. Similar results were obtained in Benin on acha (Dansi et al., 2010), yam (Loko et al. 2013) and cowpea (Gbaguidi et al. 2013).

Except for the village of Atchoukpa where no variety is threatened, in all the other villages explored, there are some endangered varieties cultivated by few households and on small areas (Table 3). The rate of diversity loss per village which varies from 20% in Azohouè-Kada to 83.33% in Sè is on average 33.82 % (Table 3). This rate represents a non-negligible loss of chili genetic resources in villages of southern Benin and it is known that varietal disappearance is undoubtedly accompanied by that of a set of genes that could be used for breeding. Therefore, it will be necessary to think about a conservation program (*in situ* and *ex situ*) for the existing diversity following Dansi et al. (2010). The main reasons (11 in total) for varietal diversity loss are variable (Table 4). The most important ones are high susceptibility to pests and diseases (65.45% of responses) and low productivity (17.67% of responses). These data are in agreement with the constraints enumerated by the producers.

The study revealed that varieties (1 to 5 per village) that have been reported as completely disappeared in a given village were fortunately found somewhere else in the study zone. As reported in cowpea (Gbaguidi et al. 2013) and yam (Loko et al. 2013) in Benin, the rate of the true diversity loss in the study zone must be lower and therefore less worrisome than the average obtained from the villages.

At households' level, the number of types (*annuum, chinense, frutescens*) of cultivated chili varies from 1 to 3 and the number of varieties within the cultivated types varies from 1 to 7. The majority of households have 1 or 2 types and 1 to 3 varieties (Figure 4). Moreover, no significant correlation was found between varietal diversity and the socio-demographic characteristics of households. This result is contrary to what was reported on yam (Baco et al. 2008, Loko et al. 2013) and cowpea (Gbaguidi et al. 2013) in Benin.

Table 3. Distribution and extent and loss of chili varieties per village

Villages	TNV	Distribution and extent				RVL
		H+A+	H+A-	H-A+	H-A-	
Adakplamè	6	3	1	0	2	33.33
Adjahomè	6	2	1	1	2	33.33
Ahoyéyé	5	2	3	0	2	40
Atchonsa	4	1	2	0	1	25
Atchoukpa	3	2	1	0	0	0
Avédjin	8	3	2	1	2	25
Azohouè-Kada	5	3	1	0	1	20
Badazouin	5	2	1	0	2	40
Damè	6	2	1	1	2	33.33
Damè-Wogon	5	2	2	0	1	20
Danhoué	6	2	1	0	3	50
Dawé	5	2	1	0	2	40
Dékpo	5	2	1	0	2	40
Dogo	6	3	0	1	2	33.33
Gangban	5	2	2	0	1	20
Gbokoutou	5	2	1	0	2	40
Hoki	8	3	0	2	3	37.5
Houèdèmè-Adja	5	4	0	0	1	20
Ichagba-Holli	5	2	1	0	2	40
Igbo-Edè	5	2	1	0	2	40
Ikpinlè	5	2	1	0	2	40
Illéchin	6	3	0	0	3	50
Koudo	4	2	1	0	1	25
Kpoba	7	3	1	1	2	28.57
Savi	6	4	1	0	1	16.66
Sè	6	1	0	0	5	83.33
Sèdjèdénou	5	3	1	0	1	20
Sokouhoué	6	3	0	0	3	50
Tangbo-Djèvié	6	3	1	0	2	33.33
Voli	8	2	1	2	3	37.5
Zounguè	3	1	1	0	1	33.33
Moyenne	**5**	**2**	**1**	**0**	**2**	33.82

NB: H: household, A: area, +/-: many or large / few or small, TNV: total number of varieties, RVL: rate of variety loss

Table 4. Principal reasons of diversity loss recorded across villages

Reasons	% of responses
Fall of plants' organs (leaves, flowers and fruits)	18.79
Low productivity	17.67
Anthracnose (Ripe rot, Shoot necrosis and leaf spots)	16.97
Fruits size too small hence attracting birds	12.12
High susceptibility to insects attacks	9.09
High susceptibility to Viruses diseases	8.48
Lack of seeds	5.45
Introduction of new varieties	4.66
Inadaptability to all types of soils (soil selectivity)	3.67
Low post-harvest storage aptitude	2.42
Susceptibility to weeds	0.68

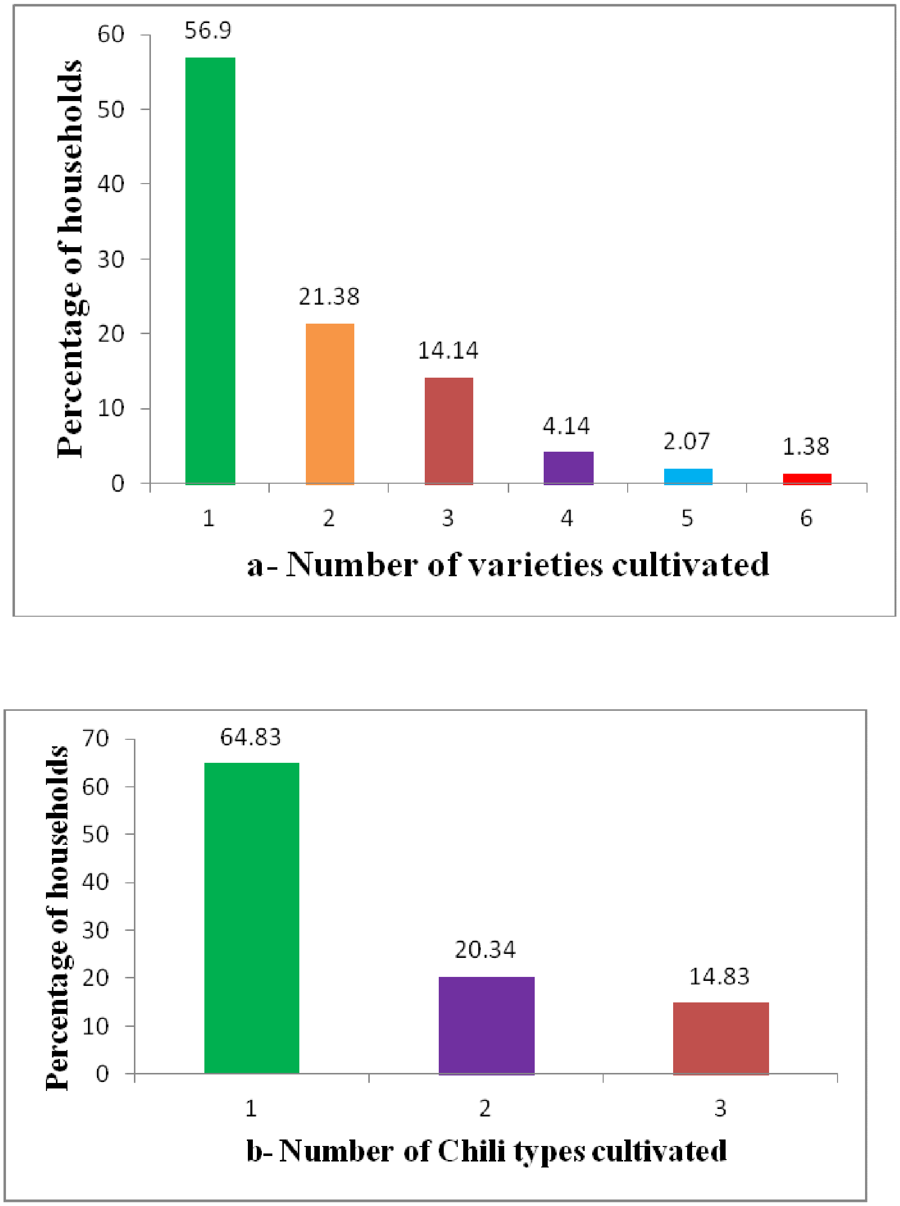

Figure 4. Number of varieties (a) and Chili types (b) cultivated per household

Farmers' varietal preference criteria

Thirteen preference criteria grouped into three categories (agronomic, technological, and economic) were mentioned by producers (Table 5). Agronomic criteria alone represent 89.88% of the responses. Among them, resistance to diseases and pests (62.72% of responses) and productivity (9.25% of responses) are the most important. At the technological level, farmers are interested in only two aspects: aroma and grinding easiness of the fruits. The economic factor absent in the raised constraints has appeared (Table 5) but still with very low importance (0.46% of responses). With regard to the constraints listed by the producers and discussed above, the identified preference criteria and their relative importance were expected. Importance given to chili aroma confirms the preference given throughout the study area to varieties of the group Gbatakin (chinense) that are naturally aromatic. As recommended by Frank et al. (2001) and Mohammed et al. (2007), for cultivated

Table 5. Farmers' variety preference criteria and their importance in southern Benin

Categories of criteria	Preference criteria	% of responses
Agronomic (89.88%)	Resistance to insects	27.62
	Resistance to early fall of the plant organs	14.62
	Resistance to anthracnose and leaf spots	10.15
	Productivity	9.25
	Resistance to virus diseases	7.7
	Good post-harvest storage aptitude	5.25
	Fruit size	4.51
	Adaptability to all types of soils	4.5
	Tolerance to drought	2.6
	Tolerance to salinity	1.62
	Tolerance to high soil moisture	1.62
	High germination rate of the seeds	1.05
Technological (9.66%)	Aroma	6.02
	Easiness of grinding	3.64
Economic (0.46%)	Market value	0.46

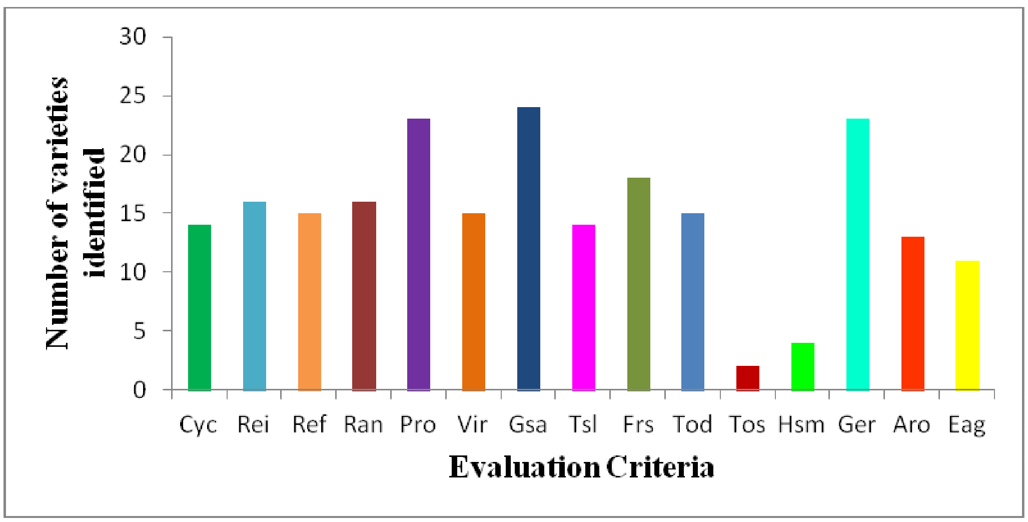

Figure 5. Number of performing varieties for each evaluated parameter

NB : Cyc : Cycle ; **Rei :** Resistance to insects; **Ref :** Resistance to early fall of the plant's organs; **Ran :** Resistance to anthracnose and leaf spots ; **Pro :** Productivity ; **Vir :** Resistance to virus diseases ; **Gsa:** Good post-harvest storage aptitude; **Tsl :** Adaptability to all types of soils; **Frs:** Fruit size; **Tod :** Tolerance to drought ; **Tos:** Tolerance to salinity; **Hsm** Tolerance to high soil moisture; **Ger :** High germination rate of the seeds; **Aro :** Aroma ; **Eag:** Easiness of grinding

plants in general, the different criteria hence identified and prioritized must be taken into account by breeders in their various chili varietal improvement programs.

Participatory evaluation of chili varieties

Participatory varietal evaluation revealed in the study zone the existence of performing varieties regarding each preference criterion (other than the economic criterion) cited above (Figure 5). Among the 36 chili varieties identified and subject to synonymy, only two (Hèbè and Hètablè) are resistant to salinity, and four are tolerant to high soil moisture and can be cultivated in the lowlands. The agronomic parameters for which great numbers of performing varieties were found are post-harvest storage aptitude of the fruits, productivity and rate of seed germination (Figure 5). Per criterion, varieties hence

Table 6. Performance of the varieties per agronomic and technological trait as reveled by the participatory evaluation

N°	Variety name	Groupes	Cyc	Rei	Ref	Ran	Pro	Vir	Gsa	Tsl	Frs	Tod	Ger	Aro	Eag	Tos	Hsm
1	Adôllôgbô	Annuum	P	s	s	s	H	s	G	Se	Ls	s	H	Na	Ha	Sb	Sb
2	Afoundja	Annuum	P	s	s	s	L	s	G	Se	Ls	s	H	Na	Ha	Sb	Sb
3	Ahouèvi	frutescens	P	r	r	r	H	r	G	G	Sm	r	H	Na	Ha	Sb	Sb
4	Alawè	frutescens	P	r	r	r	H	r	G	G	Sm	r	H	Na	Ha	Sb	Sb
5	Atawèwè	Frutescens	P	r	r	r	H	r	G	G	Sm	r	H	Na	Ha	Sb	Sb
6	Atchavavo	Frutescens	P	r	r	r	L	r	G	G	Sm	r	H	Na	Ha	Sb	Sb
7	Cader	Annuum	T	r	r	r	L	r	B	Se	Sm	r	L	A	Ha	Sb	Sb
8	Danhomètakin	Frutescens	P	r	r	r	H	r	G	G	Sm	r	H	Na	Ha	Sb	T
9	Dokppodji	Frutescens	P	r	r	r	H	r	G	G	Sm	r	H	Na	Ha	Sb	Sb
10	Ehouizo	Annuum	P	s	s	s	L	s	G	Se	Ls	s	H	Na	Ha	Sb	Sb
11	Etchindô	Annuum	P	s	s	s	L	s	G	Se	Ls	s	H	Na	Ha	Sb	Sb
12	Eyèkôdjè	Frutescens	P	r	r	r	H	r	G	G	Sm	r	H	Na	Ha	Sb	Sb
13	Gbatainkékété	Chinense	T	s	s	s	H	s	B	Se	Sm	s	L	A	E	Sb	T
14	Gbatakin	Chinense	T	s	s	s	H	s	B	Se	Ls	s	H	A	E	Sb	T
15	Gbatakindaho	Chinense	T	s	s	s	H	s	B	Se	Ls	s	L	A	E	Sb	Sb
16	Gbatakinkpèvi	Chinense	T	s	s	s	H	s	B	Se	Sm	s	L	A	E	Sb	Sb
17	GbatakinLame	Chinense	T	s	s	s	H	s	B	Se	Ls	s	L	A	E	Sb	Sb
18	GbatakinMallanville	Chinense	T	s	s	s	H	s	B	Se	Ls	s	L	A	E	Sb	Sb
19	Gbôssouanôkouin	Chinense	T	s	s	s	L	s	B	Se	Ls	s	L	A	E	Sb	Sb
20	GbôwoungodouiLame	Chinense	T	s	s	s	H	s	B	Se	Ls	s	L	A	E	Sb	T
21	GbôwoungodouiMallanville	Chinense	T	s	s	s	L	s	B	Se	Ls	s	L	A	E	Sb	Sb
22	Glazoué	Annuum	P	r	r	r	L	s	G	Se	Sm	s	H	Na	Ha	Sb	Sb
23	Hèbè	Frutescens	P	r	r	r	H	r	G	G	Sm	r	H	Na	Ha	T	Sb
24	Hèmaho	Frutescens	P	r	r	r	H	r	G	G	Sm	r	H	Na	Ha	Sb	Sb
25	Hètablè	Frutescens	T	r	r	r	L	r	G	G	Sm	r	H	Na	Ha	T	Sb
26	Hèvavo	Frutescens	P	r	r	r	H	r	G	G	Sm	r	L	Na	Ha	Sb	Sb
27	Hèviossovavo	Frutescens	P	r	r	r	H	r	G	G	Sm	r	H	Na	Ha	Sb	Sb
28	makaroni	Annuum	P	s	s	s	L	s	G	Se	Ls	s	H	Na	Ha	Sb	Sb
29	Moyotakin	Chinense	T	s	s	s	H	s	B	Se	Ls	s	H	A	E	Sb	Sb
30	Sètakin	Frutescens	P	r	s	r	H	r	G	G	Sm	r	H	A	Ha	Sb	Sb
31	Takingaga	Annuum	P	s	s	s	L	s	G	Se	Ls	s	H	Na	Ha	Sb	Sb
32	Takinkékété	Frutescens	P	r	r	r	H	r	G	G	Sm	r	H	Na	Ha	Sb	Sb
33	Tataché	Annuum	T	s	s	s	L	s	B	Se	Ls	s	L	A	E	Sb	Sb
34	Tchokossou	Annuum	T	s	s	s	L	s	G	Se	Ls	s	L	Na	Ha	Sb	Sb
35	Tchombô	Annuum	P	s	s	s	H	s	G	Se	Ls	s	H	Na	Ha	Sb	Sb
36	Vavogaga	Annuum	P	s	s	s	H	s	G	Se	Ls	s	H	Na	Ha	Sb	Sb

NB : Cyc : Cycle ; **Rei :** Resistance to insects; **Ref :** Resistance to early fall of the plant's organs; **Ran :** Resistance to anthracnose and leaf spots ; **Pro :** Productivity ; **Vir :** Resistance to virus diseases ; **Gsa:** Good post-harvest storage aptitude; **Tsl :** Adaptability to all types of soils; **Frs:** Fruit size; **Tod :** Tolerance to drought ; **Tos:** Tolerance to salinity; **Hsm** Tolerance to high soil moisture; **Ger :** High germination rate of the seeds; **Aro :** Aroma ; **Eag:** Easiness of grinding; P: early maturing ; T : late maturing; s : susceptible ; r : Resistant ; L : Low ; H : High ; G : Good ; B : Bad ; Se: selective; Ls: Large sized; Sm: Small; A: Aromatic; Na: Not aromatic; E: Easy; Ha: Hard ; T : Tolerant ; Sb : Susceptible.

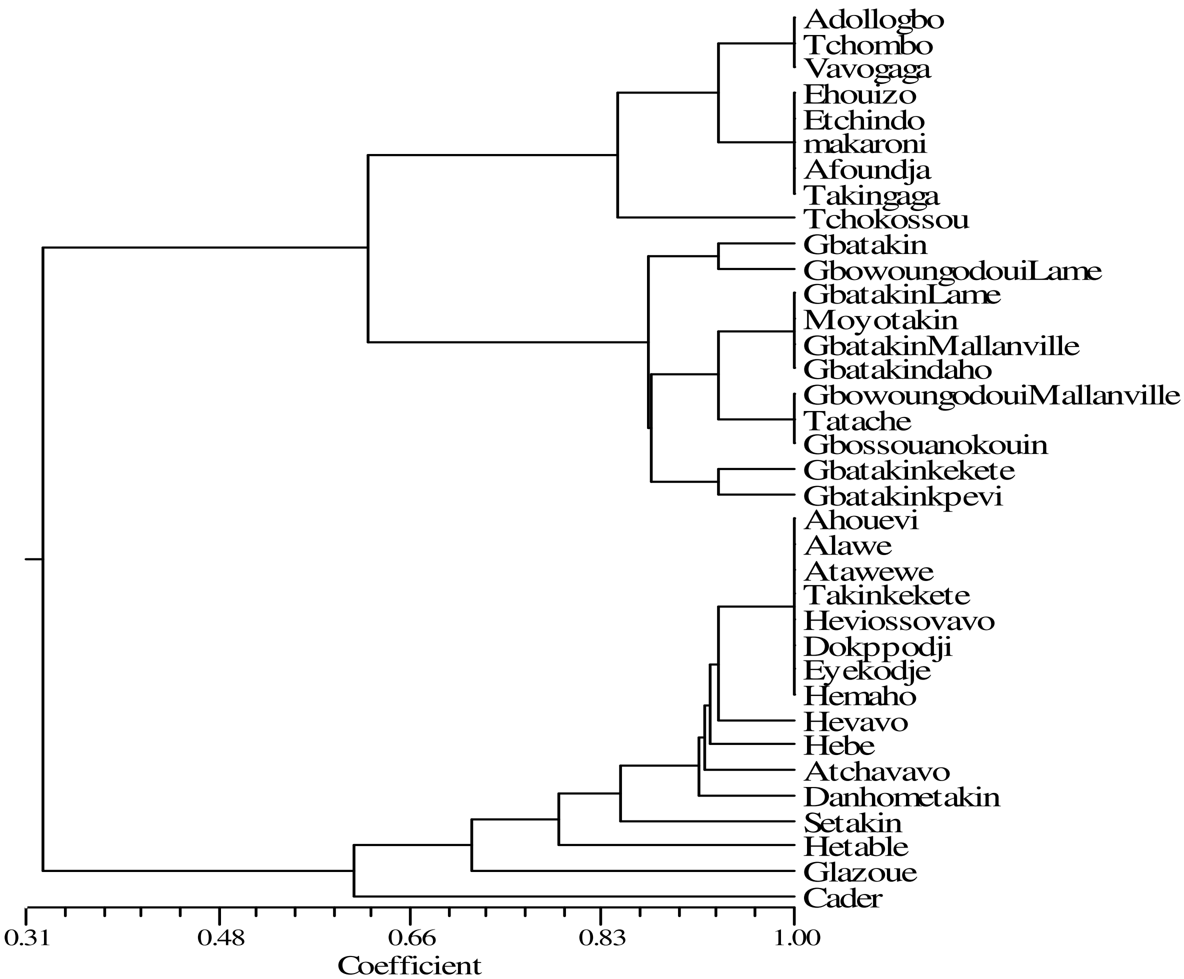

Figure 6. UPGMA dendrogram showing a partitioning of the varieties into three groups

identified constitute a pools of performing varieties that can be exploited by scientific research (breeding) and development (varietal exchanges) as it is the case now with yam in Benin.

Taken individually, good varieties showed performance for 3 to 10 agronomic parameters out of the 15 used for the participatory evaluation (Table 6). Chili varieties of the *frutescens* group are those presenting the highest performing levels (9 or 10 agronomic parameters). Considering the evaluation parameters as variables, the dendrogram constructed using UPGMA method classified varieties (taken as individuals) into 18 agronomic types grouped, at 66% of similarity, into four classes (Figure 6). Among the 18 agronomic types, five are set of different (subject to synonymy) individuals, but agronomically identical when considering together the 15 parameters used (Figure 6).

CONCLUSION

This study has allowed us to identify and prioritize constraints (biotic and abiotic) chili producers are faced with in southern Benin, document the varietal diversity and the variety’s preference criteria. With regard to the actual status of the diversity, complementary approach should be developed and implemented for conservation through utilisation of chili genetic resources in Benin and the preference criteria taken into account in breeding program. In terms of conservation, the villages of Hoki, Voli and Avédjin that presented the greatest varietal diversity are the most appropriate for *on farm* conservation programs. Very few cultivated varieties in the study zone were tolerant to abiotic stresses such as tolerance to salinity, to high soil moisture content and to drought. It is therefore important that the study be expanded to other regions of the country (the Centre and the North) in order to identify more tolerant varieties that would meet producers' and consumers' needs. Agro-morphological and molecular characterizations were also recommended for clarifying synonymies and identify duplicates. Similarly, agronomic trials should be conducted in order to confirm or deny the performance of the varieties as revealed by the participatory evaluation for their sustainable use.

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