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Full Length Research Paper

Diversity and agronomic performances of the cowpea (*Vigna unguiculata* Walp.) landraces in Southern Benin

Gbaguidi A. A.[1], Dansi A.[1*], Loko L. Y.[1], Dansi M.[1] and A. Sanni[2]

[1]Laboratoire de Biotechnologie, Ressources Génétiques et Amélioration des Espèces Animales et Végétales (BIORAVE), Faculté des Sciences et Techniques de Dassa, Université d'Abomey-Calavi, 071BP28 Cotonou, Benin.
[2]Laboratoire de Biochimie et de Biologie moléculaire, Faculté des Sciences et Techniques (FAST), Université d'Abomey-Calavi, BP 526 Cotonou, Benin

*Corresponding Author E-mail: adansi2001@gmail.com

Abstract

Cowpea is one of the major food crops contributing to food security and poverty alleviation in Benin. In order to identify performing varieties that could meet producers' and consumers' needs, and to collect ethnobotanical data that will help preserving varietal diversity, twenty eight (28) villages randomly selected in southern Benin were surveyed using participatory research appraisal. The survey revealed the existence of a non-negligible diversity of cowpea varieties in the study zone. Subject to synonymy, 92 farmer-named varieties were identified and the Shannon–Weaver diversity index (H) was estimated at 3.31. The number of varieties recorded varied from 7 to 16 per village (9 on average) and from 1 to 6 per household (3 on average). The distribution and extent analysis revealed that many varieties were being disappeared leading to a production mainly concentrated on a small number (4 on average per village) of varieties cultivated by many households and on large areas. The average rate of diversity loss was 28%. A participatory agronomic and culinary evaluation of the varieties carried out with 12 parameters yielded 3 to 76 varieties per evaluation traits. The less provided evaluation traits were tolerance to field insects, diseases, weeds and storage insects with only 3, 5, 6 and 10 varieties respectively. Based on the agronomic and culinary variables used, the 92 varieties recorded were grouped into 54 different units consisted of 1 to 11 varieties. Farmers' preference criteria were identified and prioritized for use by eventual breeding and variety exchange programmes. Identified varieties were collected and their characterization was recommended.

Keywords: Benin, cowpea, diversity, participatory evaluation, variety loss.

INTRODUCTION

Grain legumes are important source of proteins (up to 35%) for food and can therefore validly replace animal protein in the regions of the Third World where plant production is by far more important than animal production (Nelson et al. 1997). In addition to its importance in human food, cowpea is also useful for soil fertilisation through symbiotic nitrogen fixation (Diouf, 2011) and can be a major animal feed due to the quality of its leaves (Diouf, 2011). Among grain legumes, cowpea (*Vigna unguiculata* Walp.) is the most cultivated and the most consumed especially in Asia and in tropical Africa (Diouf, 2011). Its world annual production is estimated at 5249571 tonnes of dried grains of which over 64% are produced in Africa (Konan and Harold, 2007). On the African continent, West Africa represents the largest production zone (Pottorff et al. 2012).

In Benin, cowpea is the most cultivated grain legume with an annual production estimated in 2010 to be over 79,356 tonnes (FAOSTAT, 2010). According to Zannou et al. (2004) its productivity is however affected by many biotic (insects, viruses, fungi, bacteria, etc.) and abiotic factors (climate change, soil poverty and acidity, drought, etc.). Among biotic factors, field and storage insects are those causing the most severe damages that could reach sometimes 100% yield loss (Kossou et al. 2007). Following Zannou et al. (2004) and Baco et al. (2008), Benin has a wide range of cowpea landraces among

which some would be naturally resistant or tolerant to biotic and abiotic stresses and therefore useful for breeding programs. For cultivated plants in general and cowpea in particular, the use of varietal diversity or varieties naturally resistant to biotic and abiotic stresses appears today as the most environment protective approach in improving yields especially in the actual context of climate change (Kouressy et al., 2008). In Benin, contrary to yam (Loko et al. 2013) and chilli (Orobiyi et al. 2013) for which such varieties are known, in cowpea, no information related to the diversity and to the performances of the varieties is yet available for use by scientific research and development programmes.

This study, as part of a national program aiming to strengthen food security in Benin through better use of crop diversity, was designed to:

- Assess the diversity of cowpea landraces in Southern Benin
- Evaluate in participatory way the agronomic and the culinary performances of the identified landraces
- Identify and prioritise farmers' varietal preference criteria for breeding and varieties exchange purposes

MATERIAL AND METHODS

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 (Akoègninou et al. 2006). The study was conducted in the southern part of the country organised administratively in six departments (Atlantique, Littoral, Mono, Couffo, Oueme, Plateau) inhabited by ten ethnic groups (Adja, Cotafon, Holly, Ouémègbé, Pédah, Saxwè, Tori, Watchi, Xwla, and Yoruba). This region is a relatively humid agroecological zone with two rainy seasons and means annual rainfall varying from 1100 to 1400 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 (28 in total) were randomly selected throughout the different departments and ethnic areas. The name and the ethnic groups of the 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 field visits using a questionnaire following Kombo et al. (2012). In each village, interviews were conducted with the help of a local translator and groups surveyed were made with an average of 40 cowpea producers of both sexes and of different ages. In each site, local farmers' associations and the chiefs of the village were involved in the study to facilitate the organization of the meetings and the data collection. Prior to the meeting, farmers were requested in advance to bring samples of the cowpea varieties they used or knew about. The particulars of the area (agro-ecological zone, name of location, name of sub-location, name of village, ethnic group) were first collected after detailed presentation of the research objectives to the farmers. Then, farmers were asked to list (vernacular name) and display the different types of cowpea produced in their village.

The distribution and extent of the listed varieties were assessed using the Four Square Analysis method according to Kombo et al. (2012). Briefly, the Four square Analysis method classifies into four classes varieties identified in a given village base on the relative (small or vast) size of the area devoted to the variety and on the relative number (few or many) of households cultivating it (Kombo et al. 2012). Then, discussions took place on each variety with the view of understanding its status (square to which it belongs). Therefore, the reasons underlying the cultivation of each variety by few or many households and on small or large area were revealed (Kombo et al. 2012). The Four Square Analysis method is used to identify elite varieties (cultivated on large areas and by many households) and to assess the rate of variety loss.

The cowpea varieties identified were evaluated on participatory way (group of farmers), using a predefined agronomic and culinary evaluation sheet and the two-level evaluation method described by Kombo et al. (2012) and Dansi et al. (2012). In this approach and for a given variable, a variety is scored 1 when it is said to be performing and 0 when it is not. Parameters considered (12 in total) were productivity, length of the cycle, tolerance to biotic (weeds, field insects, storage insects, diseases) and abiotic (high soil moisture, drought, soil selectivity) stresses, cooking quality (cooking speed, taste, quality of the leaves as vegetable).

In each of the 28 villages explored, group discussions were followed by individual surveys conducted in 10 to 12 households randomly selected using the transect method described by Adjatin et al. (2012). In each household, the person interviewed is chosen by common agreement by the host couple according to Christinck et al. (2000). Information collected was related to the socio-demographic data (Age, sex, cultivated area in cowpea, household size, labour size, and educational level), cowpea varietal diversity maintained, and farmers' varietal preference criteria. These criteria were identified and prioritised using the matrix scoring techniques (Dansi

Table 1. List, geographical localisations and ethnic groups of the villages surveyed

Villages	Districts	Departments	Ethnic groups
Adohoun	Atiémé	Mono	Cotafon
Agongbodji	Kpédékpo	Plateau	Holly
Aguidi	Sakété	Plateau	Yoruba
Atomé	Aplahoué	Couffo	Adja
Azohouè Aliho	Tori Bossito	Atlantique	Aizo
Azohouè Balimè	Djakotomé	Couffo	Adja
Azowlissè	Avrankou	Ouémé	Ouémégbé
Dékpo	Aplahoué	Couffo	Adja
Ewè	Kétou	Plateau	Mahi
Gakpé	Ouidah	Atlantique	Fon
Gbozoummè	Avrankou	Ouémé	Ouémégbé
Honton	Dogbo	Couffo	Adja
Houin Tokpa	Lokossa	Mono	Cotafon
Hondjin	Klouékanmè	Couffo	Adja
Iladji	Kétou	Plateau	Yoruba
Illikimou	Kétou	Plateau	Yoruba
Issaba	Pobè	Plateau	Yoruba
Itadjèbou	Sakété	Plateau	Yoruba
Kinkinhoué	Djakotomé	Couffo	Adja
Koundokpoè	Zè	Atlantique	Aizo
Lagbè	Ifangni	Plateau	Yoruba
Lanta	Klouékanmè	Couffo	Adja
Lokogba	Lalo	Couffo	Adja
Odomèta	Kétou	Plateau	Yoruba
Okoakaré	Adja Wèrè	Plateau	Yoruba
Ouèdèmè Pédah	Comé	Mono	Pédah
Sahouè Doutou	Houéyogbé	Mono	Saxwouè
Sodjagohoué	Aplahoué	Couffo	Adja

et al. 2010). In total, 300 households of cowpea producers were surveyed in the 28 villages explored.

At both group and individual levels, the discussions with farmers 'groups were free, open-ended, and without a time limit being set, following Christinck et al. (2000).

Data analysis

Qualitative data were analysed using the descriptive statistics (average, percentage, etc.) and the results presented in the form of tables and figures. Shannon–Weaver diversity index (H) was computed for the whole study zone following Shannon and Weaver (1948). The rate of variety loss (RVL) at the villages 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 on small areas); **k** is the number of newly introduced varieties; **N** is the total number of varieties identified in the village. The relationships between the socio-demographic parameters of the households and the varietal diversity they have been maintained were determined with the Pearson coefficient of correlation performed with Minitab version 14 (Minitab Inc., State College, PA, USA). To study the diversity of the varieties recorded in terms of agronomic and culinary performances, a dendrogram was built using the UPGMA method (Unweighted Pair-Group Method with Arithmetic Average) and the software NTSYS-pc 2.2 (Rohlf, 2000) by considering the cowpea varieties as individuals and the evaluation parameters as variables as described by Kombo et al. (2012).

RESULTS

Cowpea diversity at community and household levels

Subject to synonymy, 92 cowpea varieties were identified in the 28 villages surveyed. Of these, 94% were local varieties and 6% were introduced in the past by the

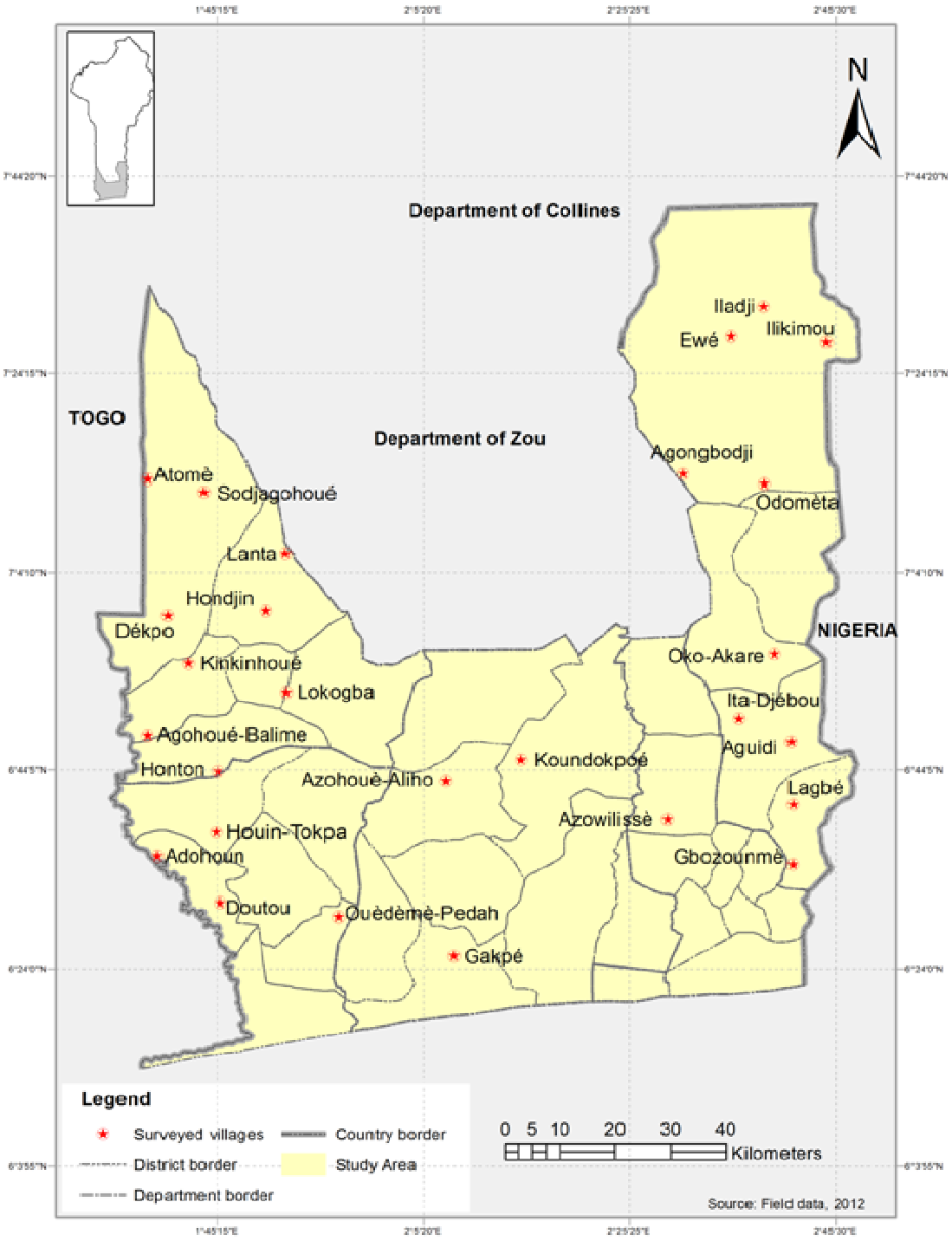

Figure 1. Map of the southern Benin showing the geographical locations of the villages surveyed

national extension services, development projects and NGOs. The number of varieties identified per village varied from 7 to 16 with an average of 9 varieties per village. Village Hondjin presented the greatest number of varieties (16 varieties) while the villages Gbozoummè and Ouèdèmè Pédah, with 7 varieties each, presented

Table 2. Distribution and extent of the varieties and rate of diversity loss across villages

Villages	TNV	Distribution and extent				NVA	VDL
		M+S+	M+S-	M-S+	M-S-		
Adohoun	9	4	2	0	3	2	22.22
Agongbodji	12	5	3	1	3	3	25
Aguidi	8	4	1	1	2	2	25
Atomé	12	3	4	0	5	5	41.66
Azohouè Aliho	7	3	1	0	3	3	42.85
Azohouè Balimè	12	11	0	0	1	1	8.33
Azowlissè	9	2	1	2	2	3	33.33
Dékpo	10	2	0	5	3	3	30
Ewè	7	3	1	1	2	0	0
Gakpé	9	6	0	1	2	0	0
Gbozoummè	7	3	1	0	3	3	42.85
Hondjin	16	8	1	1	6	6	37.5
Honton	12	2	2	2	6	5	41.66
Houin Tokpa	9	4	0	1	4	0	0
Iladji	8	3	1	4	3	2	25
Illikimou	8	3	3	0	2	2	25
Issaba	9	2	3	0	4	4	44.44
Itadjèbou	8	3	1	2	2	2	25
Kinkinhoué	10	4	2	0	4	4	40
Koundokpoè	9	3	0	2	4	3	33.33
Lagbè	8	3	2	1	2	2	25
Lanta	10	4	0	0	6	6	60
Lokogba	8	3	2	1	2	2	25
Odomèta	8	3	2	1	2	2	25
Okoakaré	8	2	1	3	2	2	25
Ouèdèmè Pédah	7	2	2	1	2	1	14.28
Sahouè Doutou	8	2	1	0	5	4	50
Sodjagohoué	14	6	3	0	4	4	28.57
Mean	9	4	1	1	3	2	28

TNV: Total number of varieties in village; M+S+: varieties cultivated by many households and on large areas; M+S-: varieties cultivated by many households and on small areas; M-S+: varieties cultivated by few households and on large areas. M-S-: varieties cultivated by few households and on small areas; NVA: number of varieties abandoned in the past; VDL: rate of varietal diversity loss (%)

the smallest number of diversity. The Shannon–Weaver diversity index (H) calculated to appreciate varietal diversity is H' = 3.31. The distribution and extent analysis (Table 2) revealed that, despite the existing diversity, only few varieties (4 on average per village) were cultivated by many households and on large areas. Subject to synonymy, Kpodjiguègué, the most widespread variety, were recorded in 42.85% of the villages surveyed. Damadami, Mahunan gbadénou and Azayou wlétchivé varieties were found in 32% of the villages. The majority of the identified varieties (54%) were rare and were not found in more than 2 villages. In many villages, a good number of varieties were being disappeared. The average rate of varietal diversity loss was 28% (Table 2). The highest rate (60%) was recorded in Lanta village. The villages of Ewè, Gakpé and Houin Tokpa presented a nil diversity los rate. Ancient varieties that have been completely disappeared in the different villages surveyed are listed in Table 3. Of these, two (Sévérine and carder petit blanc) were improved varieties introduced by the development projects. With regard to the ethnic groups and subject to synonymy, the Adja with 16 varieties presented the greatest cowpea varietal diversity. The ethnic groups Mahi and Pédah showed the smallest diversity with 07 varieties (Table 4). The highest varietal diversity loss was recorded with the Adja (37.5%), the Aïzo and the Ouémé (33.33%) ethnic groups.

At household level, the number of cultivated varieties varied from 1 to 6 (3 on average). About 55% of the households used 3 to 4 varieties, 35% cultivated 1 to 2 varieties and only 10% of the households surveyed had from 5 to 6 varieties (Figure 2). The cowpea diversity

Table 3. Vernacular names of varieties abandoned per village

Villages	NVA	Vernacular names
Adohoun	2	Ayiviyi, Vohunvo
Agongbodji	3	Ahouangbè, Sowétin, Téivi
Aguidi	2	Délékinwa, Ovinanbè
Atomé	5	Chichikpo, Djagnikpon, Kpodjiguèguè, Kakèkoun
Azohouè Aliho	3	Awawé, Damadami, Kpodji
Azohouè Balimè	1	Vohunvo
Azowlissè	3	Dannoukoun ,Kpayo,Wan
Dékpo	3	Botokpochi, Kpodjiguèguè, Nougua
Gbozoummè	3	Ayiviwéwéwiniwini, Kpodji, Wan
Hondjin	6	Avounon, Bottohoungbe, Kpéyikoun, Kpodjiguèguè, Kodonanbè, Sèwékoun
Honton	5	Azayu, Djii, Mahunangbadénou, Sèwé, Vohunvo
Houin Tokpa	4	Ayikoun wéwé, Carder petit grain blanc, Kpodji, Sèwé
Iladji	2	Atakpa, Gbaminiya
Illikimou	2	Kakotoé, Owan
Issaba	4	Choffiti, Ewa Foufou, Iyola, Olomonokpon
Itadjèbou	2	Essèomontoutou, Kakotoé
Kinkinhoué	4	Djahikpon, Kpodjiguèguè, Wlétchiaton, Wlétchivé
Koundokpoé	1	Kpodji
Lagbè	2	Sowétin, Wan
Lanta	5	Azayu, Djagnikpo, Gbolékpomè, Kpodjiguèdè, Sévérine
Lokogba	2	Kpodjiguèguè, Takpessouè
Odomèta	2	Choffiti, Olo mon o kpon
Okoakaré	2	OdjoKossi, Variété du Nigéria
Ouèdèmè Pédah	3	Kpodji, Djii, Carder (violet)
Sahouè Doutou	4	AyuWé, Botogboi, Sévérine, Sèwé
Sodjagohoué	4	Botokpochi, Damadami, Kpodjiguèguè, Takpeffochi,

NVA: number of varieties abandoned

Table 4. Distribution of the cowpea according to the sociocultural groups

Ethnic groups	NV	NVA	VDL
Adja	16	6	37.5
Aïzo	9	3	33.33
Cotafon	9	2	22.22
Fon	9	0	0
Ouémé	9	3	33.33
Holly	12	3	25
Mahi	7	0	0
Pédah	7	1	14.28
Saxwouè	8	4	50
Yoruba	9	4	44.44

NV: number of varieties; **NVA**: number of varieties abandoned; **VDL**: rate of the varietal diversity loss (%)

maintained at household level was found positively correlated to the labour size (r = 0.473 and P=0.0000), the cultivated area in cowpea (r=0.642 and P=0.0001) and the size of the household (r=0,125 and P=0.0000). No significant correlation was observed between the age of the producers, their level of education and the varietal diversity.

Farmers reported several factors affecting diversity hence justifying diversity loss (Table 5). Among them the most important were low productivity (43.22% of

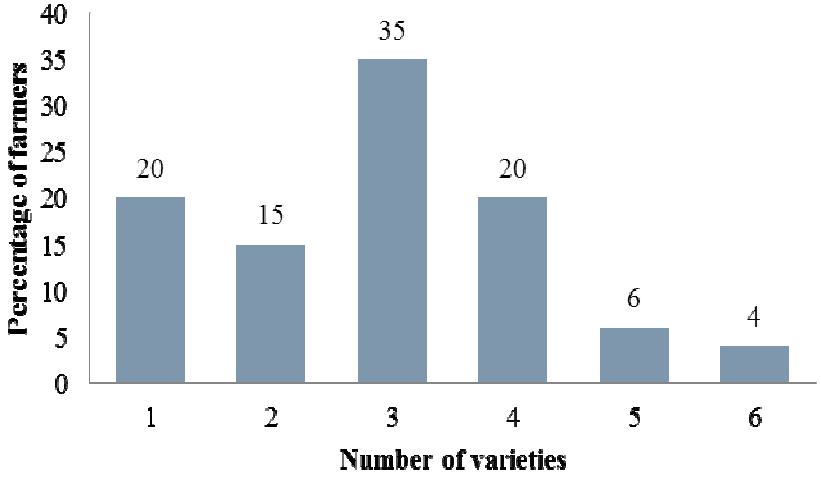

Figure 2. Diversity of cowpea maintained at households level in southern Benin

Table 5. Reasons for diversity loss and their relative importance in the study zone

Reasons	Percentage of response (%)
Low productivity	43.22
Susceptibility to poor soil	13.80
Susceptibility to pests and diseases	12.71
Introduction of new performing varieties	9.42
Difficulty of conservation	6.78
Impossibility of mixed-farming	7.14
Difficult shelling	5.38
Late cooking	1.55

responses), susceptibility to poor soils (13.8% of responses), susceptibility to pests and diseases (12.71%) and introduction of new varieties (9.42%).

Participatory evaluation of the identified varieties

Subject to synonymy and among the 92 cowpea varieties recorded and evaluated, only 29 have good productivity and 20, 18, 10, 6, 5 and 3 were reported to be tolerant to excess of rain, drought, storage insects, weeds, diseases and field insects respectively (Figure 3). For the other evaluation criteria (tolerance to all types of soil, rapidity of cooking, taste, quality of the leaves as vegetables, etc.), highly variable numbers of varieties were obtained (Figure 3).

The UPGMA dendrogram constructed based on the evaluation variables grouped the 92 varieties identified into 54 different agronomic and culinary cowpea types or units (Figure 4). The composition of these different units and their key characteristic traits are summarized in Table 6. Among the 54 identified units, 38 were made of a single variety and 16 were polyvarietal with 2 to 11 varieties (Table 6), 33 were made with early maturing varieties, 22 had good productivity and 16 were tolerant to drought (Table 6). The majority of the identified varieties (63.04%) present 2 to 4 performance criteria (Table 6). Varieties with five or more performance criteria represent 17.40% of the total diversity and those having only one performance criterion were 19.56%. At 65% of similarity, the 54 units appear clustered into 7 classes (C1 to C7) of various characteristics (Figure 4). C1 assembles 36 units composed of varieties whose leaves are good vegetable and C5 gathers varieties that are all resistant to drought, cook easily and have good taste. Seeds of selected landraces with different characteristics are shown in figure 5.

Farmers' varietal preference criteria

Twelve criteria of three different natures (agronomic,

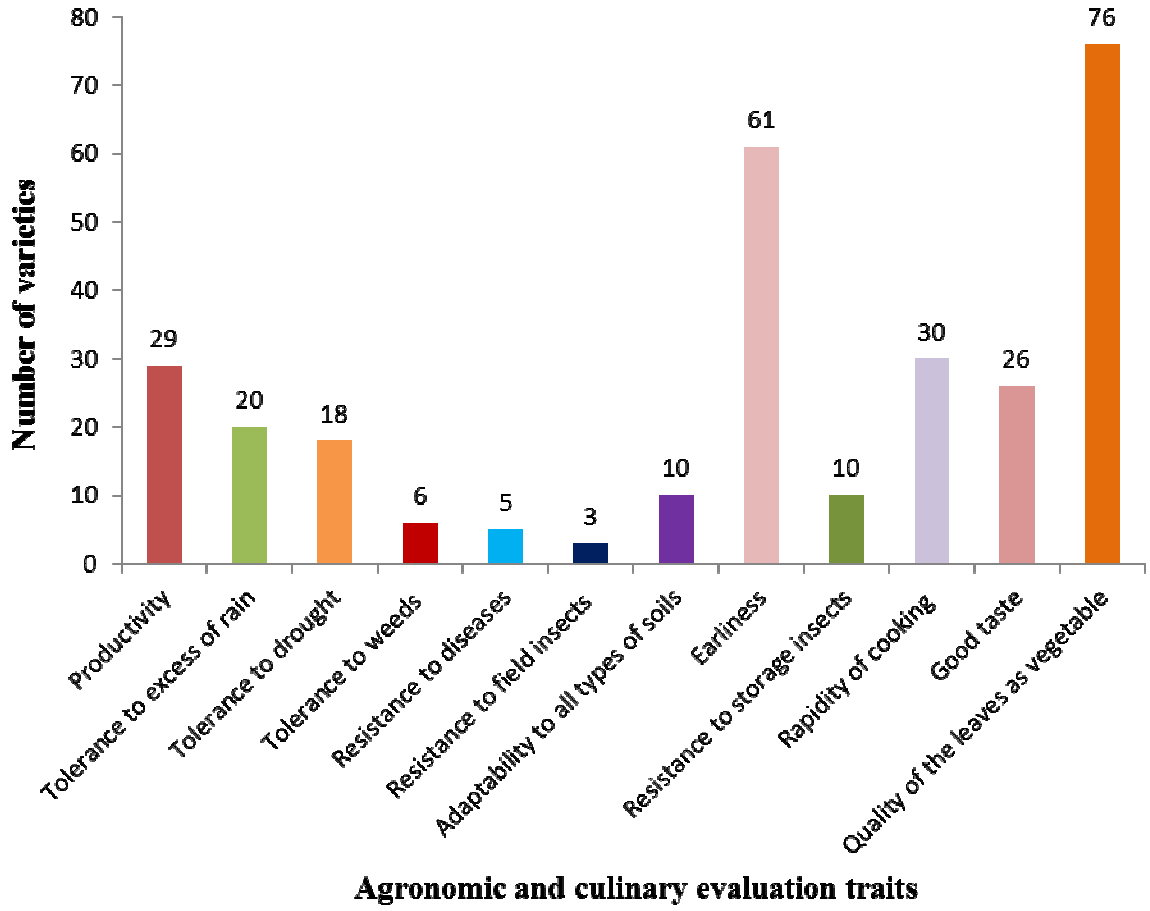

Figure 3. Number of varieties identified per evaluation traits

culinary and technological, economic) underline the choice of cowpea varieties to be cultivated in the study zone (Table 7). The agronomic criteria (seven in total) represent 74% of the responses. Among them the most important are productivity (40.82%) and resistance to insects (14.97%). Culinary and technological criteria represent 24.62% of the responses and were mainly represented by the taste (13.25% of the responses) and the rapidity of cooking (8.02% of the responses). The economic criterion represented by the market value of the grains accounts for only 1.38% of the total responses.

DISCUSSION

The surveys revealed 92 varieties classified into 54 different agronomic and culinary units constituted of varieties identical for all the 12 evaluation parameters used. This result indicates the existence of synonymies among the identified varieties. As mentioned by many authors (Mekbib, 2007, Tamiru et al. 2008, Otoo et al. 2009), vernacular names traditionally attributed to varieties vary more often across ethnic zones and villages and even sometimes between farmers within a single village. As reported with fonio (Dansi et al 2010), traditional leafy vegetables (Adéoti et al. 2009) and cassava (Kombo et al. 2012), a local cowpea variety name may designate different varieties as different local names could also indicate a single variety. Morphological and molecular characterizations are therefore necessary for clarifying synonymies and establish equivalences between local names for research and development needs as it was the case in Algeria (Ghalmi et al. 2010), Burkina Faso (Ouédraogo et al. 2010) and Kenya (Kuruma et al. 2011).

The distribution and extent analysis revealed that in almost all the explored villages, cowpea production was mainly concentrated on a small number of elite varieties cultivated by many households and on large areas while an important part of the diversity is being disappearing. This observation is not specific to cowpea. Similar results were reported on other crops such as yam (Tamiru et al.

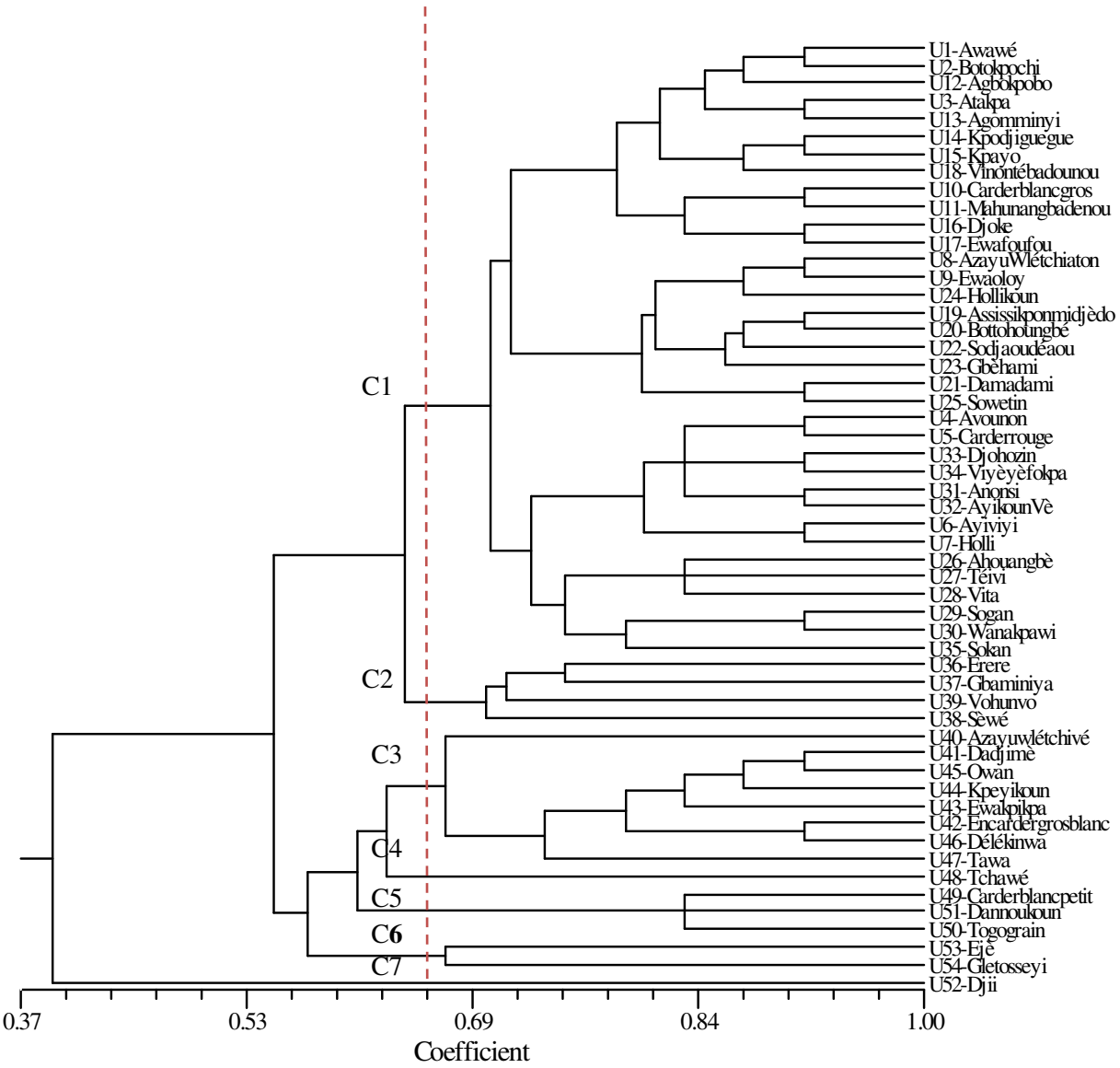

Figure 4. UPGMA dendrogram showing the classification of the varieties

Table 6. Composition and agronomic and culinary characteristics of the units of cowpea varieties identified in the southern Benin

No	NV	Name of the varieties	Agronomic and culinary characteristics
U1	6	Awawé, Choffiti, Djagnikpon, Gbagloman, Odjokossi, Yayi Boni.	Qlv
U2	11	Botokpochi, Egbanmonlou, Wan akpawé, Essèomontoutou, Gbodokpomin, Tonton, Kodonanbè, Ovinanbè, Nougua, Kpégodouiayu, Kplobè	Ear, Qlv
U3	3	Atakpa, Holavèmin, Iyola	Ear, Got, Qlv
U4	4	Avounon, Chichikpo, Variété de Nigéria, Kakotoé	Ear
U5	1	Carder rouge	Tdr, Ear
U6	1	Ayiviyi	Tdr, Twe, Ear, Qlv

Table 1 continue

U7	1	Variété de Holli	Tdr, Ear, Qlv
U8	1	Azayu Wlétchiaton	Pro, Ter, Tdr, Twe, Ats, Ear, Rac, Got, Qlv
U9	2	Ewaoloy, Gboto	Pro, Qlv
U10	4	Carder blancgros, Eguiogogo, Gominyicoun, Kponondaou	Pro, Ear, Qlv
U11	2	Mahunangbadenou, Vidé	Pro, Ear, Rac, Got
U12	4	Agbokpobo, Botogboi, Djombo, Sévérine	Ear, Rac, Qlv
U13	2	Agomminyi, Encarder gros crème	Ear, Rac, Got, Qlv
U14	2	Ayikounwéwé, Kpodjiguèguè	Rac, Got, Qlv
U15	1	Kpayo	Rac, Qlv
U16	1	Djokè	Pro, Qlv, Rac
U17	1	Ewafoufou	Ear, Rac
U18	1	Vinontebadounou	Rac
U19	1	Assissikponmidjèdo	Pro, Ter, Ear
U20	1	Bottohoungbe	Pro, Ter, Ear, Qlv
U21	1	Damadmi	Ter, Ear
U22	3	Sakaoga, Wanvi, Sodjaoudeaou	Ter, Ear, Glv
U23	1	Gbèhami	Pro, Ter, Ats, Ear, Qlv
U24	1	Hollikoun	Pro, Ter
U25	1	Sowétin	Ter
U26	1	Ahouangbè	Got
U27	1	Téivi	Twe
U28	1	Vita	Rac
U29	2	Soganakpawé, Soganakpawi	Got
U30	1	Wanakpawi	Rst, Qlv
U31	1	Anonsin	Pro, Ter
U32	2	AyikounVè, Koyan	Pro, Tdr, Ear
U33	2	Djohozin, Kakèkoun	Tdr
U34	1	Viyèyèfokpa	Tdr, Qlv
U35	1	Sokan	Tdr, Ats, Rst
U36	1	Erere	Twe, Ats, Ear, Qlv
U39	1	Vohunvo	Pro, Ats, Ear, Rst, Qlv
U40	1	Azayuwlétchivé	Rac, Got, Qlv
U41	3	Dadjimè, Olomon Okpon,Touin Touin	Pro, Ter, Ear, Rac, Got, Qlv
U42	1	Encarder gros blanc	Pro, Ter, Ear, Rst, Rac, Got, Qlv
U43	2	Ewa kpikpa	Pro, Ter, Rac, Got, Qlv
U44	1	Kpéyikoun	Pro, Rdi, Ear, Rst, Rac, Got, Qlv
U45	1	Owan	Pro, Ear, Rac, Got, Qlv
U46	1	Délékinwa	Pro, Ter, Tdr, Ear, Rst, Rac, Got, Qlv
U47	1	Tawa	Rac, Got
U48	1	Tchawé	Pro, Ter, Rfi, Ats, Ear, Rst, Rac, Got
U49	1	Crader blanc petit	Tdr, Ear, Rac, Got
U50	1	Togo grain	Pro, Tdr, Rac, Got
U51	1	Dannoukoun	Tdr, Twe, Rac, Got
U52	1	Djii	Ter, Tdr, Twe, Rdi, Rfi, Ear, Rst
U53	1	Ejè	Pro, Tdr, Rdi, Rac, Got, Qlv
U54	1	Gletosseyi	Pro, Tdr, Twe, Rdi, Rfi, Ear, Rst, Rac, Got, Qlv
U53	1	Ejè	Pro, Tdr, Rdi, Rac, Got, Qlv
U54	1	Gletosseyi	Pro, Tdr, Twe, Rdi, Rfi, Ear, Rst, Rac, Got, Qlv

NB: U: unit, NV: Number of varieties, Pro: Productivity, Ter: Tolerance to excess Rain, Tdr Tolerance to drought, Twe: Tolerance to weed, Rdi: resistance to diseases; Rfi: Resistance to field insects; Ats: adaptability to all types of soil; Ear: Earliness; Rst: Resistance to storage insects; Rac: Rapidity of cooking; Got: Good taste, Qlv: quality of the leaves as vegetable.

Figure 5: Diversity of the cowpea landraces cultivated in southern Benin as revealed by the seed morphology

Table 7. Farmers' varietal preference criteria and their importance

Categories	Farmers criteria	Percentage
Agronomics	Productivity	40.82
(74%)	Resistance to insects	14.97
	Size of seeds	8.28
	Early maturity	4.14
	Facility to shelling	2.21
	Adaptability of all types of soils	2.20
	Drought tolerance	1.38
Culinary	Good taste	13.25
(24.62%)	Rapidity of cooking	8.02
	Good leaves for vegetable	3.35
Economics (1.38 %)	Market value of the grains	1.38

2008; Dansi et al. 2013), fonio (Dansi et al. 2010), sorghum (Missihoun et al. 2012) and cassava (Kombo et al. 2012).

The rate of varietal diversity loss (VDL) was high in many villages hence indicating the need of developing strategic and concerted approaches to insure the sustainable conservation through utilization of cowpea diversity in southern Benin as recommended by Dansi et al. (2010) and JianZhang et al. (2012). The nil rates of diversity loss recorded in certain villages like Ewè, Gakpé and Houin Tokpa are not synonym of better conservation. According to the farmers these villages would have already completely abandoned varieties that were no more responding to biotic and abiotic stresses. The introduction of new varieties that are supposed to offer higher yields contributed to the abandonment of some of the existing ones. Similar observation was reported in Uganda for genetic resources in general (Mbabwine et al. 2008) and for yam in Côte d'Ivoire with the improved variety Florido of *Dioscorea alata* introduced from the West Indies (Stessens, 2002).

The average number of varieties maintained by an individual household is much lower than the total number of existing varieties. This result which is similar to those

reported on fonio in Benin (Dansi et al. 2010) suggests that there is a low overlap in the sets of varieties that each farmer grows. Therefore, there will be a need to sample several farmers, if the diversity of landraces is to be captured at a village level for on farm conservation following Jarvis et al. (2000); Maxted et al. (2002). The cowpea diversity maintained at household level is influenced by the size of the household, the importance of the available labour and the area devoted to the culture. Like with yam (Loko et al. 2013), fonio (Dansi et al. 2010) and many other crops (Jarvis et al. 2000; Maxted et al. 2002), these three parameters will be used as key basis in selecting households to be involved in an on farm conservation programme.

Subject to synonymy, the participatory evaluation of the agronomic and culinary performances of the identified varieties revealed a diversity of pools of varieties with regard to the evaluation parameters. This diversity shows the existence of a good genetic basis that can be exploited for varietal improvement as genetic diversity is the basis of a plant improvement programme (Cattivelli et al., 2008; Ghalmi et al., 2010). Varieties like Azayou wlétchiaton, Dadjimè, Carder gros blanc, Kpéyikoun, Délékinwa, Tchawé, Djii, Ejè and Gletosseyi (Table 6) that present performances for 6 to 10 criteria out of the 12 used could be considered as elite varieties usable by NGOs and development projects in some exchange programmes between villages. The study revealed that few varieties are tolerant or resistant to excess of rain, drought, soil poverty diseases and field and storage insects. In the present context of climate changes (Kouressy et al. 2008; Charrier et al. 2012) that are now becoming more and more perceptible in the regions of southern Benin, efforts should be made towards strengthening the study zone with many more varieties tolerant to biotic and abiotic stresses for the benefit of both producers and consumers and for food security.

Among the 12 varietal preference criteria identified and prioritised yield, resistance to insects and taste were the most important. The importance that producers give to these parameters in choosing varieties is not surprising. Similar results were already reported on cowpea (Kitch et al. 1998) and many other crops such as banana (Gold et al. 2002), maize (Abebe et al. 2005), teff (Belay et al. 2006), sorghum (Teshome et al. 2007), acha (Dansi et al. 2010) and cassava (Ojulong et al. 2010). In cowpea, field and storage insects are the pests causing the most important damages that can reach sometimes 100% loss (Sariah 2010, Niba et al. 2011). Therefore, one understands why resistance to insects ranks second after yield. The preference criteria hence identified and prioritized will be considered by breeders in their various cowpea varietal improvement programmes.

CONCLUSION

The study revealed the existence in Southern Benin of an important diversity of cowpea varieties that are seriously being threatened, hence calling for the development of urgent conservation strategies. Moreover, the participatory evaluation revealed the existence of some good performing varieties that can be source of interesting genes for breeding. For better conservation and utilisation of the existing diversity, synonymies must be clarified, duplicates should be identified and the genetic diversity well assessed. This calls for germplasm collection, agromorphological characterisation and genetic diversity assessment with molecular markers. We recommend that this study be expanded to the entire country for a full documentation of cowpea varieties in Benin for scientific research and development programs.

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