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Diversity of Cassava (*Manihot esculenta* Crantz) Cultivars in the Traditional Agriculture of Togo

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Abstract

Cassava (*Manihot esculenta* Crantz) is one of the major root and tuber crops contributing to food security and poverty alleviation in Togo. Unfortunately, its cultivars diversity is still not known and has even never been assessed and documented countrywide for use in breeding and development programs. To fill this gap of knowledge, 40 villages randomly selected within cassava production zones in Togo were surveyed using participatory rural appraisal. A total of 168 farmer-named cultivars were recorded. Their number varied from 1 to 15 (7 on average) per village. The highest diversity in the surveyed area was found at M'poti (15 cultivars) in Centrale region while the lowest diversity was found at Awounadjassi (1 cultivar) in plateaux region. The Shannon-Weaver diversity index (H) was estimated at 3.59 bits.The folk nomenclature was analysed and understood. The distribution and extent analysis revealed that per village few cultivars (0 to 4) are produced by many houses on large areas. The rates of cultivars abandonment risk varying from 14% to 86% (44.87% on average) depending on the village. Low productivity, late maturity and toxicity were the main abandonment reasons reported by farmer. Subject to synonymy, the participatory evaluation of the 168 cultivars inventoried yielded 37 tolerant to poor soils, 29 tolerant to high soil moisture (adaptability to lowlands), 58 tolerant to drought and 57 tolerant to weeds.The majority (132 cultivars) of cultivars were well adapted to all type of soil, 119 were able to make good quality of chips whereas 123 cultivars were non-toxic. As cassava is a vegetative propagated crop and cultivars' vernacular names vary across ethnic groups, it was recommended that the diversity be collected and fully characterized and synonymies clearly established. The results were found as of high importance for research and development actions including *ex situ* and *in situ* on farm conservation.

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Introduction

Cassava (*Manihot esculenta* Crantz) is an important food security crop in Africa that can grow in marginal environments (Howeler et al., 2013; Okogbenin et al., 2013). In tropical areas, and specifically in Africa, a large diversity of cassava cultivars is used by farmers, depending on their very local conditions (Bull et al., 2011; Okogbenin et al., 2013; Turyagyenda et al., 2012).Cassava is even considered as the least sensitive crop to climatic change in Africa (Andy et al., 2012). It can grow under less than 400 mm of average annual rainfall (FAO, 2013) by extracting water from limited and deep soils (Tewodros and Zelalem, 2015; El-Sharkawy, 2007), and when most of the other crops are not yet available, cassava is the main crop that supplies food. In comparison with other staples, cassava fresh roots and processing are also a major source of cash income for the largest number of households, and contributes positively to poverty alleviation (FAO, 2013).

Genetic diversity is known to plays a critical role in increasing and sustaining food production levels and nutritional diversity (Nellemann, 2009; Termote et al., 2012; Zannou et al., 2004). In traditional agroecosystems, farmers grow a large diversity of cultivars adapted to local conditions. These cultivars usually produce lower yields under optimal conditions than improved varieties but the relative stability of their yields provides food security to households (Barnaud et al., 2007; IFAD, 2013; Swiderska et al., 2011). Several cassava cultivars with different characteristics most often grow together in a single field, suggesting high diversity within this crop (Siqueira et al., 2009; Alves-Pereira et al., 2011), which is important for plant breeding programs (Mezette et al., 2013). However, according to Siqueira et al. (2009), studies concerning cassava diversity are scarce when compared with the great ethnical and territorial diversity of populations that grow cassava.

In Togo, cassava is the most cultivated crop with an annual production estimated in 2013 to be over 902,860 tons (FAO, 2015). However, since 1993, cassava yield is decreasing (Country STAT-Togo, 2014; FAO, 2015). Banito et al. (2007) reported that this could be due to high incidences of cassava bacterial blight, cassava mosaic disease and cercosporioses across ecological zones of Togo and suggested the development of improved varieties. Productivity depends on agricultural practices, degree of fight against plant parasites and diseases but also and mostly on varieties that are used. These varieties are still not yet well known and documented in Togo. This study was conducted to:

- Assess the current status of the cassava diversity in Togo.
- Understand the folk nomenclature related to its cultivars across zones.
- Establish, in participatory way, the profile of the existing cultivars with regard to key agronomic, technological and culinary traits for use in plant breeding and development programs.

Materials and methods

Study area and sites selection

With a total land area of 56600 km², the republic of Togo is divided into five administrative regions (Maritime, Plateaux, Centrale, Kara and Savanes) and 36 districts or sub-districts. Its population, unequally distributed across regions, was 6 191 155 habitants in 2010 (RGPH4, 2010) and is increasing at an annual rate of 2.84% (RGPH4, 2010). The country is inhabited by 41 ethnic groups of variable importance. Annual rainfall varies from 800 to 1400 mm. the most humid regions is Plateaux region while the less humid is Maritime region. For the study, 40 villages were selected across 27 districts where cassava is mainly cultivated (Fig. 1). Districts were selected based on the production statistics (agricultural campaigns 1991 to 2010) from the Ministry of Agriculture. Inside districts villages were selected with the help of the agricultural extension workers on the basis of ethnic diversity. Three villages were selected in each of Vo, Yoto and Zio districts that have a cassava production area over 10 000 ha. Two villages have been selected in each of the seven districts (Tchaoudjo, Lacs, Bassar, Sotouboua, Blitta, Haho and Moyen Mono) having 5000 to 10 000 ha of cassava area. In each of the 17 districts with less than 5 000 ha of cassava production area, one village was selected. At all, 13 villages within 11 districts of Plateaux region, 13 villages within 6 districts of Maritime region, 7 villages within 6 districts of Kara region and 7 villages within 5 districts Central region were surveyed.

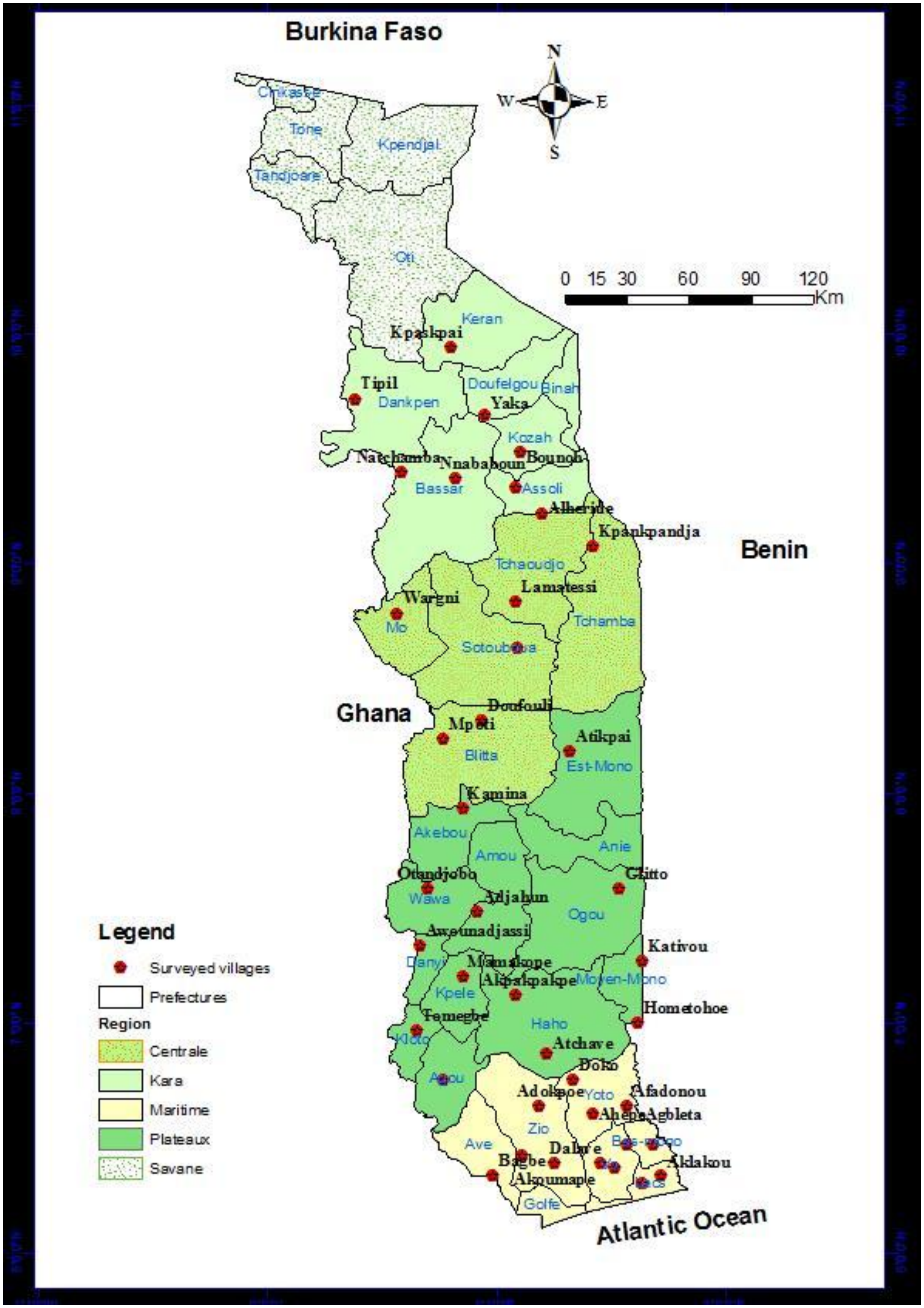

Fig. 1: Map of Togo showing the administrative regions and the localization of the villages surveyed.

Survey methodology

Data were collected during expeditions from the different sites through the application of participatory research appraisal tools and techniques, such as group discussions and field visits following Kombo et al. (2012). In each site and with the help of locally recruited translators, a group meeting was organized with 20 to 30 farmers (both men and women) of different ages. Local farmers' associations and agricultural extension workers were also involved in this study to facilitate the organization of the meetings and data collection. Information on the location (name of district, name of village, ethnic group) was first collected after a detailed presentation of the research objectives to the farmers. After this, farmers were asked to list and display the different cassava cultivars they grow in their village. For each cultivar, the vernacular names and its meaning, the cycle and its origin were documented. The distribution and extent of the cultivars were assessed using the Four Squares Analysis approach described by Orobiyi et al. (2013). This approach helps, at community level and on participatory way, to classify existing cultivars into four groups: cultivars cultivated by many households on large areas; cultivars cultivated by many households on small areas; cultivars cultivated by few households on large areas, and cultivars cultivated by few households on small areas. After this, discussions moved to the detail of each cultivar with the objective of understanding the reasons for their status. Hence, reasons that justify the cultivation of each cultivar by many or few households and on large or small areas were documented. Discussions were free, open-ended, and without a time limit being set following Kombo et al. (2012). Identified cassava cultivars were assessed against 26 agronomic, technological and culinary traits of economic importance (Table 1) with the two-level scoring evaluation method described by Dansi et al. (2013) and Loko et al. (2013).

Table 1. Parameters used in theparticipatory evaluation of cassava cultivars in Togo.

Categories of variables	Evaluation parameters	Scoring
Agronomic	Productivity	High- Low
	Earliness	Yes – No
	Adaptability to all types of soil	Tolerant-Sensitive
	Tolerance to poor soils	Tolerant-Sensitive
	Tolerance to high soil moisture	Tolerant-Sensitive
	Tolerance to drought	Tolerant-Sensitive
	Resistance to virus diseases	Resistant- Sensitive
	Resistance to anthracnose	Resistant- Sensitive
	Resistance to cochineal	Resistant- Sensitive
	Resistance to bacterial diseases	Resistant- Sensitive
	Tolerance to weeds	Tolerant- Sensitive
	Resistance to root rot (after wound)	Resistant- Sensitive
	In ground post maturity storage ability	Good – Low
Technological and culinary	Cortex ability to detach	Easy-difficult
	Friability	Friable-non friable
	Taste	Sweet – bitter
	Toxicity	Toxic-Non toxic
	Fiber content	High- Low
	Starch content	High- Low
	Quality of tapioca	Good – bad
	Yield in *Gari*	High- Low
	Quality of *Gari*	Good – bad
	Quality of the chips	Good – bad
	Chips resistance to storage insects	Resistant- Sensitive
	Quality of leaves as vegetables	Sweet – bitter
	Ability to ferment when cut in water	Fast-slow

Data analysis

Collected data were analyzed through descriptive statistics (frequencies, percentages, averages, etc.) to generate tables and figures at different (villages, ethnic areas and regions) levels using Excel 2007. Shannon–

Weaver diversity index ($H' = -\sum PiLnpi$) was computed for the whole study zone following Shannon and Weaver (1948) with:

$$\text{Pi} = \frac{ni}{N}$$

Where, ni = number of cassava cultivars in each village; **N =** sum of ni.

The rate of cultivars' loss (RCL) was calculated per surveyed village following Gbaguidi et al. (2013) by using the following formula.

$$RCL = \frac{\text{n - k}}{\text{N}} x\, 100$$

Where, n = number of cultivars cultivated by few households on small areas, k = number of newly introduced cultivars and N = total number of cultivars recorded in the village.

To analyze the degree of resemblance between the elite cultivars (cultivars produced in at least one village by many households on large area), 11 well-known parameters (precocity, productivity, resistance to weed, in ground post maturity storage ability, resistance to root rot (after wound), cortex ability to detach, friability, taste, toxicity, fiber content, quality of leaves as vegetables) were considered. The elite cultivars were considered as individuals and the parameters as variables and coded 1 or 0 as the estimated variable is applicable or not. Based on the simple matching coefficient of similarity and the software NTSYS-pc (version 2.2.) the complete binary matrix obtained was used to construct a dendrogram with the unweighted pair-group method with arithmetic average (UPGMA) cluster analysis (Rohlf, 2000). The geostatistical modelling approach known as ordinary Kriging was used following Dansi et al. (2013) to analyze the spatial distribution of the cassava cultivars diversity throughout the country. Ordinary Kriging (OK) is a commonly used linear spatial interpolation method which provides estimates of variables at unsampled locations by using information from neighboring points and assigning weights to these points based on their distance from the point being estimated and the spatial variability structure (Bilgili, 2013; Hennequi, 2010). It represents the average variance between observations separated by a distance ***h*** and has a strong descriptive and interpretative power for the structure of the spatial variability of a variable (Merckx et al., 2010). Kriging provides not only predictions but also the prediction errors or Kriging variances at each prediction location. The spatial auto-correlation is quantified through a function called a semi-variogram. A semi-variogram is represented as a graph and reveals the underlying spatial patterns of variables, having more similar values when they are spatially closer (Merckx et al., 2010). This semi-variogram was computed from:

$$\gamma(h) = \frac{1}{2n} \sum_{i=1}^{n} (Z(x_i) - Z(x_i + h))^2$$

Where, Z(xi), in this study, is the cultivar diversity (number of cultivars that exist) in the village i, Z(xi +h) is the cultivar loss of other villages separated from xi by a discrete distance h; n represents the number of pairs of observations separated by h, and γ (h) is the estimated or "experimental" semi-variance value for all pairs at a lag distance h. Semi-variances were calculated for each possible pair of sampling villages, and the average values of semi-variances were plotted for increasing distance intervals (h) to produce the experimental semi-variogram. The semi-variogram is represented as a graph and reveals the underlying spatial pattern of variables, having more similar values when they are spatially closer. In this study, the spatial prediction of cultivar loss was based on the geographical information (latitude, longitude) collected with GPS in the 40 villages surveyed. The Kriging maps were constructed using ArCGIS 10.1.

Results

Cassava cultivars diversity at village level

A great diversity of cassava cultivars was found throughout the surveyed villages. A total of 168 differently named cassava cultivars were recorded in the study area. This varies from one zone to another (Table 2). The Shannon diversity index (H') was 3.59 bits. The majority (126) of the cultivars were native while the remaining were originated from Ghana (23 cultivars), Benin (14 cultivars), Cameroun (2 cultivars), Gabon (2 cultivars) and Madagascar (1 cultivar). Per villages, cassava diversity varied from 1 to 15 with 7 on average. The highest diversity (15 cultivars) was observed in M'poti village which belongs to Blitta prefecture (central region) and the lowest (1 cultivar) was registered in Awounadjassi village (Table 2) at Danyi prefecture (Plateaux region).

Table 2. Diversity of cassava cultivars per region in Togo.

Regions	NV	MiNc	MaNc	SI	Average
Maritime	13	4	11	1.35	8±0.71
Plateaux	13	1	9	1.00	5±0.61
Centrale	7	3	15	0.65	7±1.41
Kara	7	3	11	0.59	6±1.06

NB: NV: Number of village surveyed; SI: Shannon Index; MiNc: Minimum number of cultivars; MaNc: Maximum number of cultivars.

The analysis of distribution and extent of cassava cultivars in the study area revealed that, on average, only 2 over 7 cultivars were produced by many households and on large areas whereas 3 cultivars on average were cultivated by few households and on small areas (Table 3).

Table 3. Diversity, distribution and extent, and threat of cassava cultivars in Togo.

Regions	Villages	TNC	Distribution and extent				NIC	RCL
			H+A+	H+A-	H-A+	H-A-		
Centrale	M'poti	15	1	2	2	10	0	67
	Wargni	6	2	1	0	3	0	50
	Niamgoulam	6	0	4	0	2	0	33
	Kpankpandja	3	1	1	0	1	0	33
	Doufouli	6	2	0	0	4	2	33
	Lama-tessi	7	2	2	1	2	0	29
	Alhéridè	6	1	1	1	3	2	17
Kara	Natchamba	5	1	0	0	4	0	80
	Yarayara	11	1	2	3	5	1	36
	Kpaskpaï	3	0	1	0	2	1	33
	N'nababoun	7	3	0	2	2	0	29
	Bounoh	7	3	1	0	3	2	14
	Yaka	7	1	4	0	2	1	14
	Tipil	3	0	3	0	0	0	0
Maritime	Ativeme	10	1	0	1	8	0	80
	Ahépé-Agbléta	8	2	0	0	6	0	75
	Mome-Hounkpati	11	2	0	1	8	0	73
	Aklakou	6	2	0	0	4	0	67
	Afadonou	6	1	0	1	4	0	67
	Attikple	10	3	1	0	6	1	50
	Ganave	10	2	2	1	5	0	50
	Vo-Afowuime	11	3	1	1	6	1	45
	Bagbé	11	4	1	1	5	0	45
	Akoumape	5	1	0	2	2	0	40
	Dôko	6	1	3	0	2	0	33
	Dalavé	4	2	0	0	2	1	25
	Adokpoe	6	4	0	1	1	0	17
Plateaux	Akpakpakpe	7	1	0	0	6	0	86
	Tomegbe	6	1	0	0	5	0	83
	Kativou	6	1	0	0	5	0	83
	Glitto	8	0	2	0	6	0	75
	Mamakope	3	1	0	0	2	0	67
	Adjahun	5	0	0	2	3	0	60
	Atikpaï	7	2	1	0	4	0	57
	Hometohoe	4	1	1	0	2	0	50
	Atchavé	3	1	0	1	1	0	33
	Agbavé	9	1	5	0	3	0	33
	Kamina	6	3	1	0	2	0	33
	Awounadjassi	1	1	0	0	0	0	0
	Otandjobo	5	2	1	1	1	1	0
Average in the study zone		**7**	**2**	**1**	**1**	**3**	**1**	**44.87**

TNC= total number of cassava cultivars per village; H+A+ = many households on large areas; H+A- = many households on small areas; H-A+ = few households on large areas, H-A- = few households on small areas; NIC = newly introduced cassava cultivars; RCL = Rate of cultivars loss.

Cassava cultivars cultivated by many households and on large areas are considered as elite cultivars. Considering the number of cultivars per village, the map constructed using the ordinary Kriging approach revealed three diversity zones (Z1, Z2, Z3; Fig. 2) within the surveyed area. Region of Savanes was not surveyed. The number of cultivars per village, according to this method, is 1 to 3 in Z1 (Upper north of Kara region), 3 to 8 in Z2 (the entire Plateaux region and many areas of others regions) and 8 to 15 in Z3 (part of region Maritime and Centrale region).

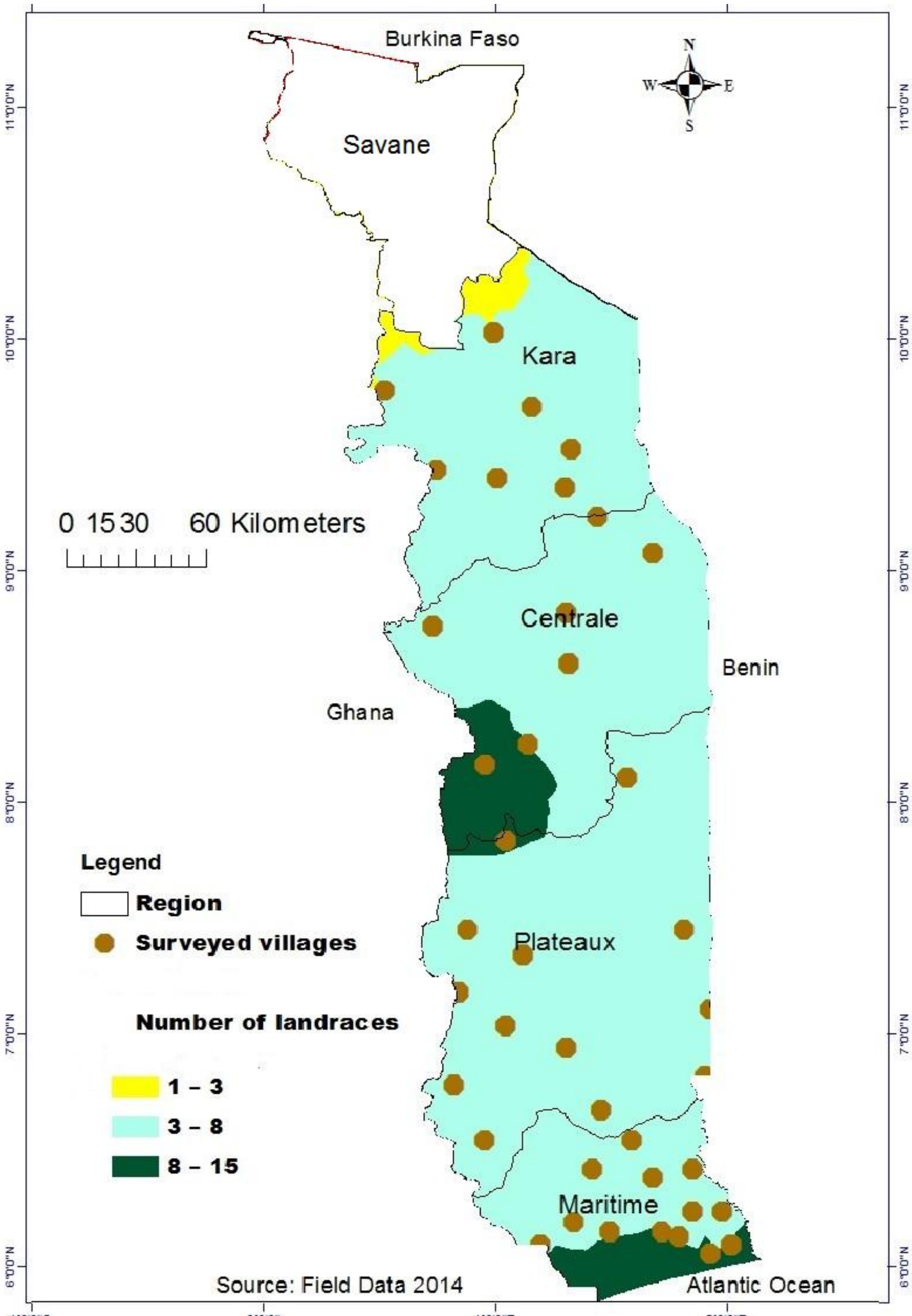

Fig. 2: Geographical distribution of cassava cultivars diversity in Togo.

Among the 168 cassava cultivars recorded in the study area and subject to synonymy, 41 cultivars are reported by the producers as cultivated by many households and on large areas (Table 5) in their villages. One of them (Gbazé) was found elite in all the 7 villages in which it has been listed. Seven of those cultivars (Koudokpo, Cameroun, Beninvi, Gabon, Lagosivi, SORAD and Bazoka) are elites in more than two villages of the study area. Kataoli and Faintomigbodji for instance are elites in only one village. The elite cultivars have good agronomic (high productivity, earliness, good in-ground storage aptitude, etc.), culinary or technological (non-toxicity of roots, good quality of *gari*, good quality of chips, friability, etc.) performances.

Table 5. List, maturity cycle, distribution and extent of the elite cassava cultivars in Togo.

Nº	Cultivars	Maturity cycle (months)	Distribution and extent
1	Akpahé	6	Atchave (+ +)
2	Assomé	12	Atikpaii (+ +)
3	Atidjin	12	Vo-Afowime (+ +)
4	Aziakpo	6	Bagbe (+ +)
5	Bazoka	6-18	Adokpoe (+ +), Ativeme (- +), Dalave (+ +), Doufouli (+ +), M'poti (+ +)
6	Beninvi/ Beninvinon	6	Ativeme (+ +), Dalave (+ +), Lamatessi (- -), M'poti (+ -), Otandjobo (+ +), Tomegbe(- -)
7	Cameroun	6-12	Awounadjassi (+ +), Kamina (+ +), Otandjobo (+ +)
8	Degaule	24	Lamatessi (+ +)
9	Djolaoba	6-18	Attikplè (- -), Yarayara (+ +)
10	Donmeyibô	6	Attikplè (+ +),
11	Faintomigbadji	7-13	Akpakpakpe (- -), Ativeme (- -), Bagbe (- +), Doko (- -), Hometoe (- -), Kativou (+ +),
12	Gabon/Gabonvi	6-18	Adjahun (- -), Alheride (- -), Bounoh (+ +), Doufouli (+ +), Lamatessi (+ +), Mamakope (- -), Tomegbe (- -), Agbave (+ -), Ativeme (- -)
13	Gavonakouté	12	Adokpoe (+ +)
14	Gbanzé/Gbazé/ Gbézé	6	Akoumape (+ +), Ahepe-Agbleta (+ +), Doko (+ +), Mome-Hounkpati (+ +), Vo-Afowime (+ +), Afadonou (+ +), Hometoe (+ +),
15	Vivigbazé	6	Attikple (+ +)
16	Gbérikpèle	10	Kamina (+ +)
17	Johnson	8-12	Tomegbe (+ +)
18	Kambon bantchi	12	Natchamba (+ +)
19	Kataoli/Katôwolé	12	Afadonou (- -), Aklakou (- -), Attikple (- -), Ganavé (+ +), Mome-Hounkpati (- -), Vo-Afowime (- -)
20	Kisseimou koutowou	24	Nnababoun (+ +),
21	Kodjoabouyi	12	Adopoe (+ +)
22	Kolmon kamkam	12	Nnababoun (+ +),
23	Kolmon Sissawou	18	Nnababoun (+ +),
24	Koudokpo	6-12	Aklakou (+ +), Ganavé (+ +)
25	koutonwou 2	6	Bounoh (+ +),
26	koutonwou 3	6	Bounoh (+ +),
27	Lagosivi/ Lagoskouté	6-8	Afadonou (- +), Ahepe-Agbleta (+ +), Aklakou (+ +), Akoumape (+ -), Attikplè (+ +), Ganavé (+ -), Mome-Hounkpati (+ +), Vo-Afowime (+ -)
28	Nana	6	Bagbe (+ +)
29	Nigeria kikpado	12	Wargni (+ +)
30	Nigeria Kissaimon	12	Wargni (+ +)
31	N'kougo/ Adidoyo	6	Bagbe (+ +)
32	ôdongbo	12	Attikpaii (+ +)
33	Sassakawa	6	Mamakope (+ +)
34	SORAD		Alheride (+ +), Bounoh (- -), Kpankpandja (+ +), Natchamba (- -), Nnababoun (- -), Yarayara (- -)
35	Takata	6	Yaka (+ +)
36	Tchitchakpoé	10-12	Adokpoé (+ +)
37	Tététidadjin	12	Vo-Afowime (+ +)
38	Tséviékouté	6-8	Akpakpakpe (+ +)
39	Tuaka	6-18	Ahepe-Agbleta (- -), Ativeme (- -), Kamina (+ +),
40	Wôna	12	Bagbe (+ +)
41	Wouti	6	Agbave (+ +)

At 65% of similarity, the dendrogram constructed using the UPGMA method to determine the relationships between the 41 elite cultivars in terms of performance revealed five groups (Fig. 3). Group 1 (G1) is formed by 5 cultivars resistant to weeds and of bitter and toxic roots but with leaves consumed as vegetables (Table 6). Group 2 (G2) has six non-friable cultivars with bitter roots, low fiber content bitter leaves and difficult detachable cortex. Group 3 (G3), with 4 cultivars that have low in-ground post maturity storage aptitude (roots that deteriorate when the time of harvest is exceeded), non-friable and non-toxic root with easy detachable cortex and high susceptibility to weeds.

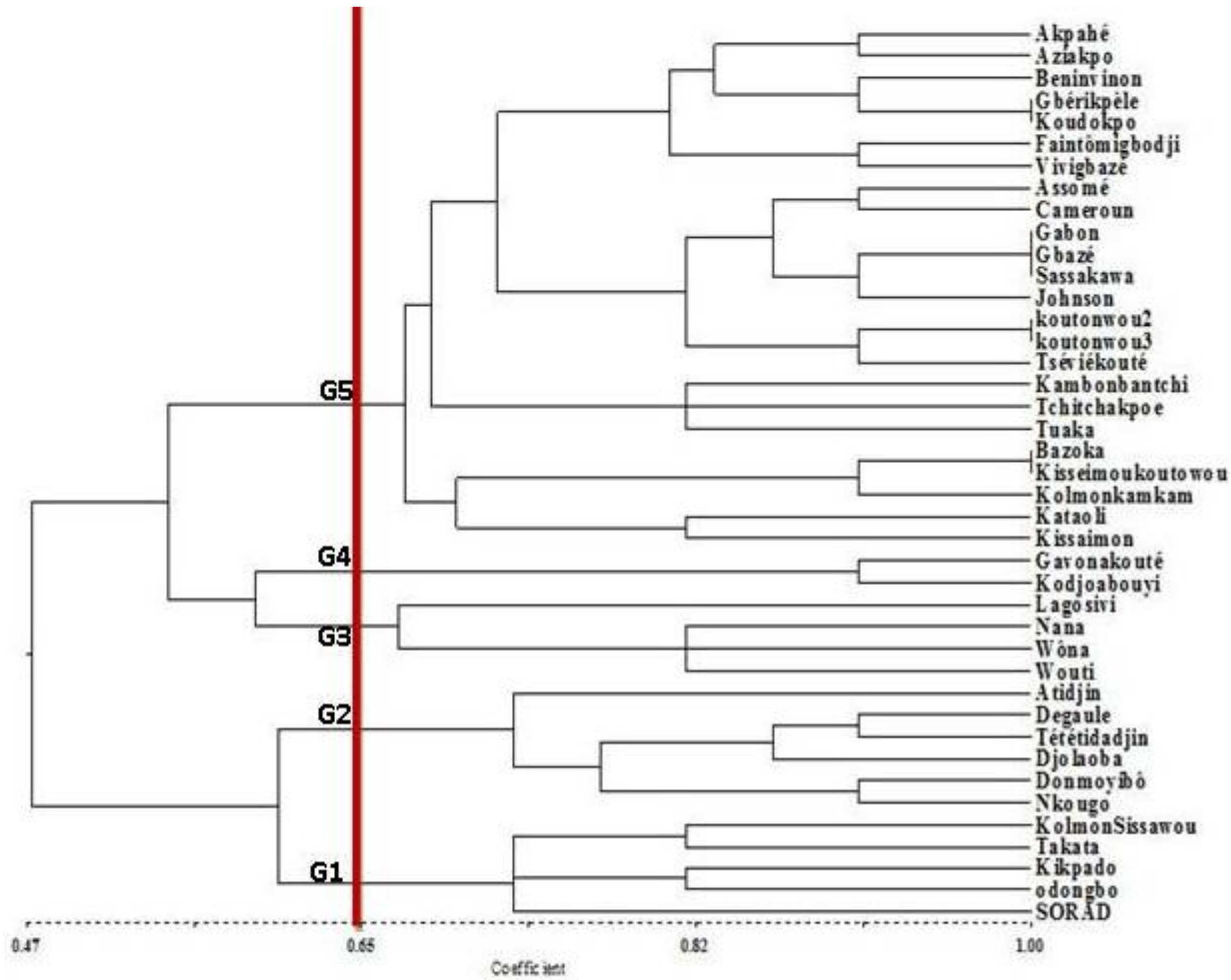

Fig. 3: Dendrogram constructed with the UPGMA method showing grouping of the elites cassava cultivars.

Group 4 (G4), with only (2) cultivars susceptible to weeds that have no toxic and friable root with easily detachable cortex, late maturity cycle, low productivity, poor post maturity in-ground storage aptitude. Group 5 (G5) is mainly formed by twenty-four (24) cultivars that have both leaves and roots with good taste and not toxic (Table 6).

In Niamgoulam, Kpaskpaï and Tipil villages, no elite cultivar was recorded and more than the third of the cultivars mentioned were produced by many households and on small areas for family consumption. They have exceptional culinary characteristics (good quality of the pounded root) but their productivity is low, they are very late maturing and sometimes susceptible to virus diseases. Cassava cultivars cultivated by few households and on large areas are soil-selective or newly introduced. The number of cultivars per ethnic groups varies from 1 to 15. The lowest number (1) was found with the Ahlon and the highest number was recorded with the sociocultural group Adele (Fig. 4).

Table 6. Groups of elite cassava cultivars and their agronomic and culinary characteristics.

Group	Cultivars	Agronomic and culinary characteristics										
		Cyc	Pro	Rtw	Ipa	Raw	Cad	Fr	Taste	Tox	Fc	Qlv
G1	Kolmon Sissawou	L	High	Res	Bad	Sus	Eas	NF	Bitter	T	Low	Sweet
	Kikpado	L	High	Res	Good	Res	Eas	NF	Bitter	T	Low	Sweet
	ôdongbo	L	High	Res	Good	Sus	Eas	Fri	Bitter	T	Low	Sweet
	SORAD	L	High	Res	Good	Sus	Dif	NF	Bitter	T	High	Sweet
	Takata	Ear	High	Res	Bad	Sus	Dif	NF	Bitter	T	Low	Sweet
G2	Atidjin	L	High	Sus	Good	Res	Dif	NF	Bitter	NT	Low	Bitter
	Degaule	L	High	Sus	Good	Sus	Dif	NF	Bitter	T	Low	Bitter
	Djolaoba	L	High	Res	Good	Sus	Dif	NF	Bitter	T	Low	Bitter
	Donmoyibô	Ear	High	Sus	Bad	Sus	Dif	NF	Bitter	NT	Low	Bitter
	N'kougo	Ear	High	Sus	Bad	Sus	Dif	NF	Bitter	T	Low	Bitter
	Tététidadjin	L	High	Sus	Bad	Sus	Dif	NF	Bitter	T	Low	Bitter
G3	Lagosivi	Ear	High	Sus	Bad	Res	Eas	NF	Sweet	NT	High	Sweet
	Nana	Ear	High	Sus	Bad	Sus	Eas	NF	Bitter	NT	High	Bitter
	Wôna	L	High	Sus	Bad	Sus	Eas	NF	Bitter	NT	Low	Bitter
	Wouti	Ear	High	Sus	Bad	Sus	Eas	NF	Bitter	NT	Low	Sweet
G4	Gavonakouté	L	Low	Sus	Bad	Sus	Eas	Fri	Sweet	NT	Low	Bitter
	Kodjoabouyi	L	Low	Sus	Bad	Sus	Eas	Fri	Bitter	NT	Low	Bitter
G5	Akpahé	Ear	High	Res	Bad	Sus	Eas	Fri	Sweet	NT	Low	Sweet
	Assomé	L	High	Res	Good	Sus	Eas	Fri	Sweet	NT	Low	Sweet
	Aziakpo	Ear	High	Sus	Bad	Sus	Eas	Fri	Sweet	NT	Low	Sweet
	Bazoka	L	High	Res	Bad	Sus	Eas	Fri	Sweet	NT	High	Sweet
	Beninvinon	Ear	High	Sus	Bad	Sus	Dif	NF	Sweet	NT	Low	Sweet
	Cameroun	L	High	Res	Good	Res	Eas	Fri	Sweet	NT	Low	Sweet
	Faintômigbodji	Ear	High	Sus	Good	Sus	Dif	Fri	Sweet	NT	Low	Sweet
	GaBon	Ear	High	Res	Good	Res	Eas	Fri	Sweet	NT	Low	Sweet
	Gbazé	Ear	High	Res	Good	Res	Eas	Fri	Sweet	NT	Low	Sweet
	Gbérikpèle	Ear	High	Sus	Bad	Sus	Dif	Fri	Sweet	NT	Low	Sweet
	Johnson	Ear	High	Res	Good	Sus	Eas	Fri	Sweet	NT	Low	Sweet
	KamBon bantc	L	High	Sus	Good	Sus	Eas	NF	Bitter	NT	Low	Sweet
	Kataoli	L	High	Sus	Good	Res	Eas	Fri	Sweet	NT	High	Sweet
	Kisseimou koutowou	L	High	Res	Bad	Sus	Eas	Fri	Sweet	NT	High	Sweet
	Kolmon kamkam	L	High	Res	Bad	Sus	Eas	Fri	Sweet	NT	Low	Sweet
	Koudokpo	Ear	High	Sus	Bad	Sus	Dif	Fri	Sweet	NT	Low	Sweet
	koutonwou 2	Ear	High	Sus	Good	Res	Eas	Fri	Sweet	NT	Low	Sweet
	koutonwou 3	Ear	High	Sus	Good	Res	Eas	Fri	Sweet	NT	Low	Sweet
	Kissaimon	L	High	Res	Good	Res	Dif	Fri	Sweet	NT	High	Sweet
	Sassakawa	Ear	High	Res	Good	Res	Eas	Fri	Sweet	NT	Low	Sweet
	TcHightchakpoé	L	High	Res	Good	Sus	Eas	NF	Sweet	NT	Low	Sweet
	Tséviékouté	Ear	High	Sus	Bad	Res	Eas	Fri	Sweet	NT	Low	Sweet
	Tuaka	L	High	Sus	Good	Sus	Eas	Fri	Sweet	NT	Low	Sweet
	Vivigbazé	Ear	High	Res	Good	Sus	Dif	Fri	Sweet	NT	Low	Sweet

Cyc = Cycle; Pro = Productivity; Rtw = resistance to weeds; Ipa = In-ground post storage ability; Raw = Root rot after wound; Cad = Cortex ability to detach; Fc = Fibber content, Fr = Friability, Tox = Toxicity; Qlv = Quality of leaves as vegetables; Ear = early, L= late; Res = resistant; Sus = Susceptible; Eas = Easy, Dif = difficult; Fri = friability; NF = Not friable; T = toxic; NT = Not toxic.

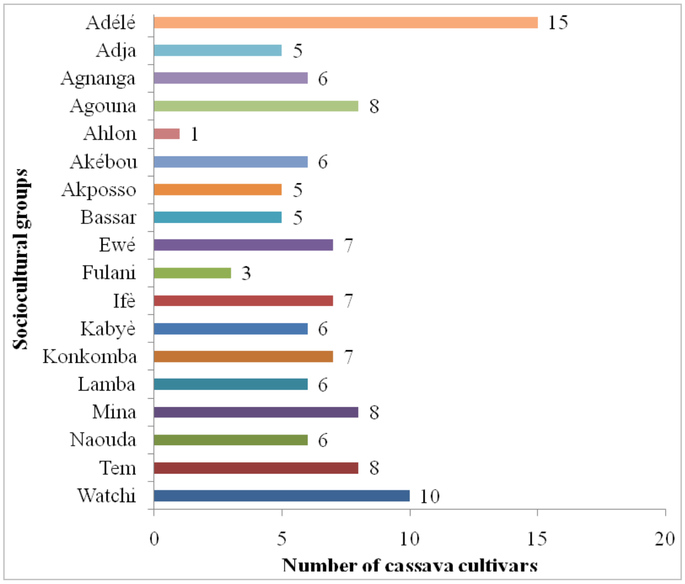

Fig. 4: Cassava cultivars diversity per ethnic groups in Togo.

In Ahlon, Adele and Ewe sociocultural groups, less than 15% of the cassava cultivars found are toxic while in Agnaga, Agouna and Akebou sociocultural groups most (18 over 19) of the elite cassava cultivars are non-toxic.

Generally the bitter cultivars are used to produce *gari* by traditional way. In Ife, Konkomba and Fulani (Fulani of Tchamba prefecture) ethnic groups, cassava is mainly used as chips (dried tuberous roots). 29% to 67% of the cassava cultivars found in those communities are toxic. Also, in Watchi, Tem and Mina ethnic groups, which are specialized in *gari* production, respectively 30%, 35% and 42% of their cultivars were said to be toxic. In the remaining ethnic groups, the number of toxic cultivars ranged from 17% to 25%.

Folk nomenclature of cassava cultivars in the study area

In the study area the majority (89%) of cassava cultivars names have a meaning (Fig. 5) that refer mostly to the origin (24% of cultivars). It is, for instance, the case of cultivars Assome, Gabon and Cameroun (Table 7). Other cultivars names are linked to the leaves, the stem and root colors (14% of cultivars). Cultivars Doméyibô (black top buds), Akpadjin (red cortex), Akpahé (white cortex), Atidjin (red stem) are examples of this group.

Table 7. Names of some cassava cultivars and their meanings.

Cultivar	Meaning	Ethnic groups
Agbanayô	Full the pot	Adele
Akpadjin	Red cortex	Adja, Ewe, Mina, Watchi
Akpahé	White cortex	Ewe
Aladevi	Cassava introduced by the famer Alade,	Ewe
Bassila	Name of locality of origin	Ewe
Assouma	Eat without care	Lamba
Atamè	Don’t worry	Akposso
Atidjin	Red stem	Watchi
Atiyibô	Black stem	Mina
Awou	Produce without noise	Akposso
Bazoka	Produce highly like the noise of the gun	Adele, Agnanga, Ewe
Boussoun n'sian	Six months	Ashanti
Commando	Top buds red like the hat of commando soldiers	Agouna
Doazanninfintô	Reassure creditor	Ewe, Mina, Watchi
Doméyibô	Black top buds	Watchi
Egouhnla	Wasteful work	Watchi
Faintômigbodji	Creditor be patient	Adja, Ewe, Watchi
Kambombantchi	Cassava of Kamboni ethnic group	Konkomba
Lamou	Consumable	Komkomba, Kabye
Madoumakou	Eat and die	Watchi
Péla	Lasting for many years before producing	Ewe
Sodjavi	Fast like military	Watchi

Others cultivars names refer to the architecture (height and shape) of the plant (11% of cultivars), the productivity (9% of cultivars), the culinary characteristics (8% of cultivars) and the precocity (6% of cultivars).

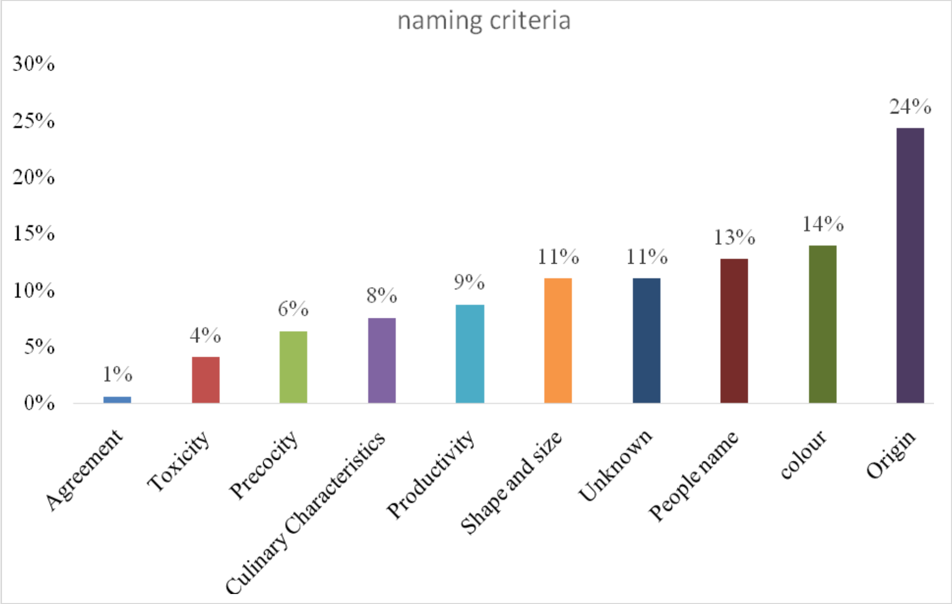

Fig. 5: Naming criteria of cassava cultivars.

Treats on cassava cultivars across surveyed sites

Across sites, and apart from Tipil, Awounadjassi and Otandjobo villages, the rate of cultivars under threat (RCT) varies from 14% to 86% with an average of 45%. The highest rates (75% to 86%) were recorded in the villages of Ahépé-Agbleta and Ativemé (Maritine region), Glitto, Tomégbé, Kativou, Akpakpapé (Plateaux region) and Nachamba (Kara region). Relatively low rates (14 to 33%) were found in Bounoh, Yaka, N'nababoun and Kpaskpaï for Kara region, Ahéridè, Lama-tessi, Niamgoulam, Kpankpandja and Doufouli villages for central region, Atchavé, Agbavé and Kamina for Plateaux region, Adokpoe, Dalavé, Dôko for costal region.

Nine key reasons grouped into two categories justify the threat on the cultivars. Within the agronomic reasons, low productivity (33.72%), long maturity cycle (23.82%) and introduction of new cultivars 23 (12.22%) were the most important (Table 8). Toxicity of the roots (16.86%) is, according to the producers, the principal culinary and technological reason of cultivars abandonment.

Table 8. Reasons of cultivars loss at community level.

Categories	Reasons	Percentage of responses
Agronomic (76.75%)	Low productivity	33.72
	Late maturity cycle	23.84
	Introduction of new cultivars	12.22
	Sensibility to root rot	4.07
	Sensibility to drought	1.74
	Selectivity to soil	1.16
Culinary and technological (23.25%)	Toxicity	16.86
	Root full of water	5.23
	Bad quality of *gari*	1.16

Participatory evaluation of the cultivars

The participatory evaluation of cassava cultivars reveals the existence of some performing cultivars well-known by farmers (Fig. 6). The majority (132 cultivars) of evaluated cultivars are well adapted to all types of soil, 119 were able to make good quality of chips whereas 123 cultivars are non-toxic. Subject to synonymy, 57 cultivars can make good quality of tapioca, 58 are tolerant to drought stress, 79 have good friability, 90 are known to have good quality of *gari*, 97 have high productivity, 102 have good in ground post maturity storage ability and 119 are suitable for making good quality of chips.

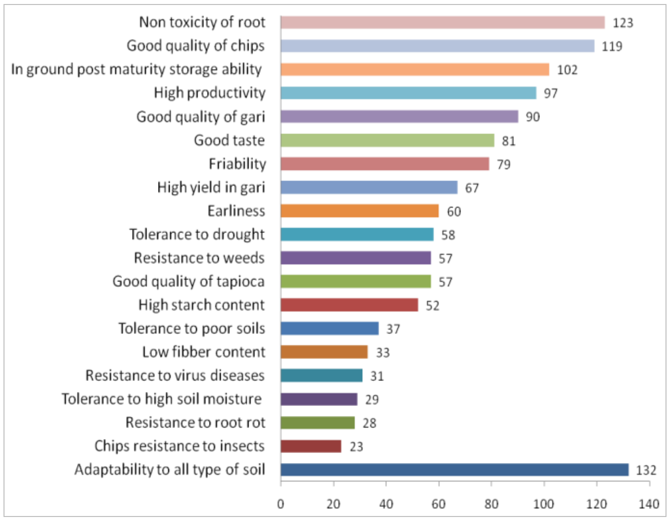

Fig. 6: Number of performed cassava cultivars by evaluated traits.

Discussion

This study is the first survey focusing on cassava cultivars diversity in Togo. It involved a lot of farmers within different agricultural systems, different ethnic groups and socio-economic conditions. Throughout the forty (40) villages surveyed, only 41 elite cultivars were found out of the 168 recorded subject to synonymy. These elite cultivars were those presenting interesting agronomic (high productivity, earliness of the plant cycle, good in ground storage ability), technological (good quality of *gari*, tapioca and chips) and culinary (good taste, friability, good ability to be pounded) characteristics. The relative importance of non-elite cultivars is in support of the hypothesis that farmers in Togo are still doing subsistence farming by maintaining and propagating existing diversity. Similar results were reported by Yemataw et al. (2016) in Ethiopia and Zietz and Seals (2006) in Mexico. This study also revealed, like it was the case in Benin (Agre et al., 2015) an unequal distribution of cultivars throughout surveyed sites.

In the study area, a lot of cultivars have been recorded by their names. As reported by many authors (Adjatin et al., 2012; Kombo et al., 2012; Dansi et al., 2013), in the traditional system of vernacular nomenclature of crop, local names often vary from one ethnic group to another and sometimes from one village to another within the same sociocultural group (Loko et al., 2013; Gbaguidi et al., 2013). This could lead to an overestimation of diversity (Tamiru et al., 2008). In fact, it is highly uncertain that all the farmer-named cultivars recorded correspond to genetically distinct genotypes. Morphological characterization combined with molecular analysis should be conducted in order to detect duplicates and establish equivalence between names.

Most of cultivars are being abandoned for various reasons. This result is in agreement with the report of Agre et al. (2015) on cassava, Lung'aho (2012) on potato, Gasura and Mukasa (2010) and Ngailo et al. (2016) on sweet potato; Kashenge-Killenga et al. (2014) on rice. Many elite cultivars have been listed in more than 5 villages. The widespread distribution challenges the view that traditional farming systems are isolated and closed, with limited exchange of germplasm (Tamiru et al., 2008). Furthermore, as Tamiru et al. (2008) indicated, this result depict these farming systems rather as open and dynamic, where local networks exist for moving planting materials across wider areas and heterogeneous environments. In spite of the existing diversity (7 cultivars in average per village) in the study zone, only 2 cultivars were elites. These 2 cultivars per village are widely cultivated mainly because of their high productivity and their early maturity. Farmers maintain diverse cassava cultivars, not only with respect to attributes such high productivity, environmental adaptation and length of growing period but also with respect to their own consumption habit. In Niamgoulam, Kpaskpaï and Tipil villages having nil (Tipil) or relatively low cultivars loss rate (up to 33%), there was no elite cultivar and cassava is cultivated mainly for family consumption. This indicates that the villages that are cultivating varieties according to market demand are always looking for the best varieties that fit this demand. Therefore, they are losing the ancient varieties at high rates. The cultivars' distribution and extent analysis revealed that most of them are under severe threats of disappearance and the production efforts at village level seems to be concentrated on a small numbers of cultivars cultivated by many households and on large areas. Therefore, it is necessary to develop sustainable conservation strategies to preserve the actual diversity for use by both present and future generations.

The inventoried cultivars don't have the same distributions, and moreover the knowledge related to technologic utilization of cassava cultivar varies from one village to another. Some of the surveyed people were experienced with products issued from the processing of cassava root like *gari*, chips, tapioca and starch in some of the villages while many others were not. Also, the use of non-toxic or toxic cultivars was directly associated to ethnic groups. The composition of manioc inventories of each community therefore, also reflects the culinary traditions of each ethnic group (Peña-Venegas et al., 2014). The lowest diversity was recorded in Ahlon's ethnic group. Nevertheless, Ahlon ethnic group stated during the survey that the consumption of the cassava (boiled and pounded roots) is closely linked to their food habits. In Watchi, Mina and Ewe groups which are living in Maritime region (the most populated), cassava, apart from being their food, represents also a source of important income which replaces the cotton "as crop cash". Cassava production in these groups reflects the market driven demand aroused by the migratory flows of populations in urban areas that could impact cultivars diversity if it happens that only few high yielding varieties were used. But the preservation of this diversity depends on ethnic trends to maintain their eating habit.

Fulani people do not have cassava and its by-products as food habit. They have been influenced by the consumption habit of the local populations with whom they found lands to settle many years ago. Moreover during the group survey they said that they belong to the Fulani-Tem ethnic group. It is after discussions they explain that they settled down at Tem land for a long time. These last findings reflect the changing food habit aroused by cohabitation of different ethnic groups in the same location. Results of this study revealed the existence of an average diversity of cassava cultivars in Togo.

Conflict of interest statement

Authors declare that they have no conflict of interest.

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