

Biodiversity of local varieties of corn cultivation among farmers in Benin

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Abstract. *Zea mays* L. is a widespread cultivated cereal. In Benin, this crop is an important food source and highly contributes to food security. Though it is important in Beninese food habits, there is a lack of scientific information about the traditional knowledge and uses of corn in Benin. Thus, the aim of our study was to investigate on local corn varieties knowledge and producers' endogenous practices. To achieve this objective, a total of 233 producers from four ethnic groups were randomly selected and surveyed in 92 villages in Benin. During this investigation, information on maize varieties was collected from selected producers using a participatory research approach through a semi-structured questionnaire kind. Also, the maize samples were collected from the investigated producers. Our results show that 19 different local names were given to both local cultivars and improved varieties of corn cultivated in Benin. Though the white color is the major color, three other colors (yellow, red and multicolor) were recorded during our field investigations. The corns are mainly produced for local consumption, trade and a small proportion for traditional medicine. Farmers reveal that old farming techniques, conservation of harvest, parasites and drought-related problems are essentially the major constraints to maize production. The traditional preservation methods of corn are conservation as cobs and/or as grains (with or without chemical preservatives) followed by regular daylight drying. The producers developed some selection methods to maintain their local cultivars. This information will help to better promote maize genetic resources management and utilization in Benin.

Keywords: Endogenous knowledge, producers, *Zea mays*, farming techniques, conservation, Benin.

Abbreviations: CFA, Correspondence factorial analysis; Ali, Alibori; Ata, Atacora; Atl, Atlantique; Bor, Borgou; Col, Colline; Cou, Couffo; Don, Donga; Mo, Mono; Oué, Ouémé; Pla, Plateau; Zou, Zou.

INTRODUCTION

Maize or corn is an annual tropical herbaceous plant belonging to the Plantae kingdom, Poaceae family genera and species *Zea mays* (Anzala, 2006). This cereal is one of the most important grains in the world and thus, over the last decades, has recorded a large diversification in the use of its different components. Indeed, besides the diversified traditional uses in feeding, maize plant is now

wildly used in many fields such as animal feeding, energy, fertilization, industry, pharmacy (Aboua et al., 1989; Bricas et al., 1994; Kagne et al., 2003). So its use in many fields as animal feed (poultry, pigs, cattle) and in industries (brewing, soap and oil mill) induce an extension of the cultivated areas (Boone et al., 2008).

The world production of maize is in decrease and was

estimated in 2013 at about 27,700 kg/s (~839 million tons) against 860 million tons for a consumption of 866.7 million tons in 2012 (Planetoscope, 2013). In Benin, it occupies more than 700,000 hectares representing about 35% of total cultivated surfaces (Soulé et al., 2008) and is today the most consumed cereal far more than rice and sorghum (Sodjinou et al., 2007).

In most of West African countries such as Benin, corn is cultivated all over the country and is the main (85%) base of rural people diet (Nago et al., 1997). Though farmers use traditional agricultural methods, we denote a very diverse range of corn varieties (locals and improved) grown according to the main aim of the producers. Among those varieties, local ones were reported to be mostly used by traditional farmers (Missihoun et al., 2012) despite that improved varieties display the best agronomic performance. However, despite their high agronomic performance, the improved corn varieties developed by research centers are less adopted by peasants. This under adoption of improved varieties is not only because of the extra work and expense induced but also because they have different organoleptic and technologic qualities from local ecotypes (Kydd, 1989; Koudokpon, 1991; CIMMYT, 1991; Tchamo, 1993) and their ability to resist abiotic and biotic stresses (N'Diaye, 2001). Furthermore, studies on agrobiodiversity in Benin confirmed the desire and enthusiasm of people to produce and use local varieties (Dossou-Yovo, 2000). Thus, traditional and local varieties still occupy a significant place in the national production. In order to safeguard agro-biodiversity, it is urgent to index, describe and preserve all local varieties for next generations. Thus, despite its importance demonstrated in the Beninese agricultural system, there is no reliable database on the characteristics of maize the local varieties. The aim of this study was to analyze the biodiversity of local corn varieties grown in Benin.

MATERIALS AND METHODS

Study zone

The survey of different corn accessions was conducted in 92 villages selected in the Northern, Center and Southern Benin, West Africa (Figure 1).

Sampling

The selection of villages was done randomly following the methods previously described by Dansi et al. (2008, 2009). To specify our selections some criteria like corn production, accessibility and socio-cultural groups were added before the final retention of the village. Once the village is retained, producers belonging to a group of older people, young producers, opinion leaders and wise men were selected based on their indigenous knowledge.

The sample is primarily composed of indigenous peasants; otherwise they were replaced by immigrants.

Information collection

A total of 233 producers belonging to four ethnic groups (Kwa, Gur, Senegambians, Yoroboids) (INSAE, 2003) were surveyed during our investigation. Data were collected using a participatory research by direct observation techniques, individual interviews, field visits through a semi-structured questionnaire type. Some time (inaccessibility of corn fields), focus group were held in public places (schools, youth centers, etc). The collection slip was conceived in order to record information on the location (agro-ecological zone and village), language, ethnic group, local maize name and some personal information about of respondents. In the end, general information on the origin, agronomic performances and crop management of each producer were recorded.

Data analysis

Data were processed with Microsoft Excel 2010 spreadsheet. The Correspondence Factorial Analysis (CFA) was realized by Minitab software.

RESULTS

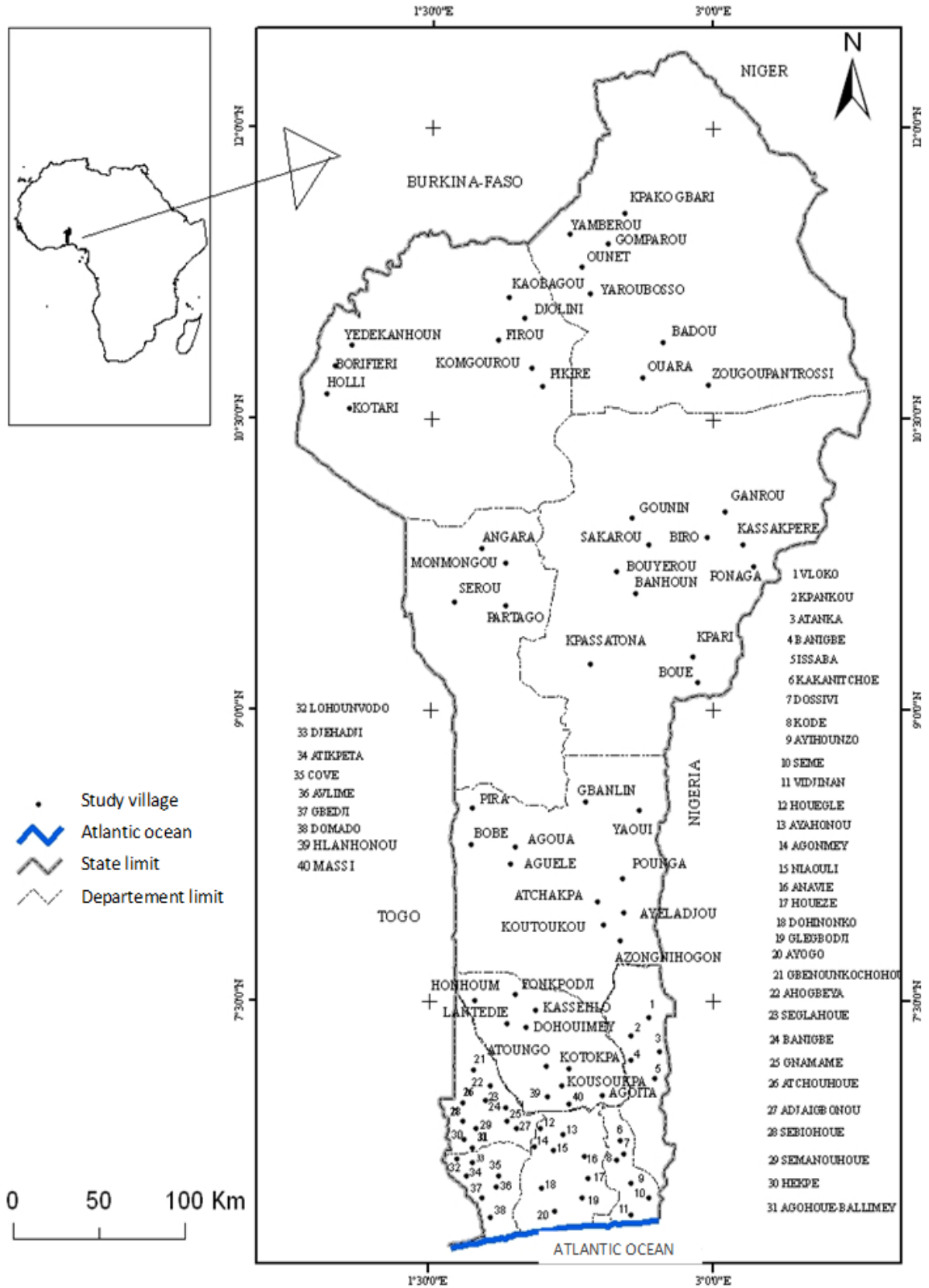
Local names of maize in Benin

Of the 23 dialects listed in our study, 19 local names for maize have been identified (Table 1). Maize has mainly a single name by local language. Nevertheless, dialects attributed three ("gbaa, Gbadé and Gbayé" by Kotafon) or two names ("Gbèrènou or Mandé" by Bariba) to this cereal. Moreover, we record the same name in two ("Agbado" by Nagots and Holly) or three ("Gbado" by Goun, Idatcha and Tchabè) different languages.

The languages listed can be classified into four ethnic groups (Table 2).

Maize cultivars status

In Benin, there are local cultivars and improved varieties of grown maize. Globally, the local cultivars are the most cultivated (67.8%). Considering the departments, local cultivars are grown mainly in Atlantic (100%) and in Alibori (96%) whereas improved varieties are much adopted in Donga (87.5%) (Figure 2a). Preference was also observed according to ethnic group. Thus, we noticed a strong use of local varieties by the Senegambian ethnic group (92.9%) while improved varieties are much adopted by the Gur group (55.6%) (Figure 2b).



Source: Fond topographique IGN, 1992

Realisation : LaCarto/DGAT/FLASH/UAC, 2015

Figure 1. Location of the study area.

Table 1. Different designations corn based on department and dialects.

Local names	Departments										Language	
	Ali	Ata	Atl	Bor	Col	Cou	Don	Mo	Oué	Pla		Zou
Agbado					+					+		Nagot Holly
Akpabra Akroko		+					+					Gourmantché
Gbado					+					+		Goun Idatcha Tchabè
Kokoli Kokoliri	+											Peulh
Gbèrènou Mandé	+			+								Bariba
Bayia		+		+								Biali
Baffo					+		+					Adja Itcha
Gbaa Gbadé Gbayé					+	+		+		+	+	Kotafon
Gbaa			+									Tori aïzo
Gbayé						+						Fon Mahi
Sakayou		+										Naténi
Wa mla					+			+				Lokpa kabyè
Manzo Mran Soya Yèmariyo Yovo							+				+	Yom Waman Ditamari Sahouè

Ali: Alibori; Ata: Atacora; Atl: Atlantique; Bor: Borgou; Col: Colline; Cou: Couffo; Don: Donga; Mo: Mono; Oué: Ouémé; Pla: Plateau; Zou: Zou. +: indicated the language and local name is used in the department.

Varietal diversity of maize depending on the color

The study reveals that in Benin white, yellow, red and multicolor corns are current (Figure 3). We observe a predominance of white colored corns (65.7%) followed by yellow (25.3%), multicolor (4.7%) and the red (4.3%)

(Figure 4a). The white variety is grown in all the departments with high preference observed in the department of Collines (95.7%). The yellow variety is not grown in Atacora whereas the highest production level (80%) is recorded in Alibori. The red variety is much cultivated in Atacora (33.3 %) (Figure 4b). Regarding the

Table 2. Distribution of languages in ethnic groups.

Ethnic group	Languages
Kwa	Adja, Houeda, Sahoue, Aïzo, Kotafon, Mina, Fon, Mahi, Goun, Tofin, Xwla
Gur	Bariba, Ditammari, Berba, Waama, Gurma, Natimba, Lokpa, Coto-Coli, Kabye, Yom, Yoa, Taneka
Sénégambiens	Fulani
Yoroboids	Yoruba, Idaasha, Nagot

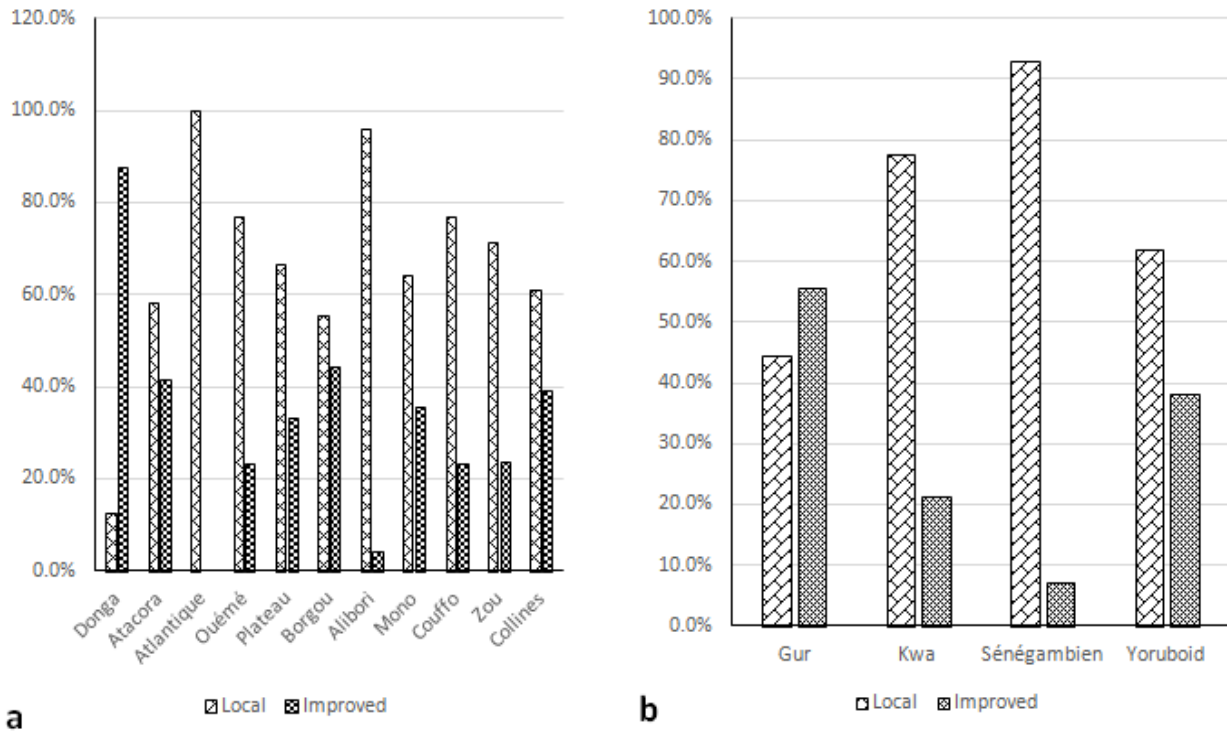


Figure 2. Different types of varieties exploited according to departments (a) and ethnic groups (b).

ethnic groups, our data shows a greater adoption of white varieties by Yoruboids (90.5 %) while 57.1% of yellow varieties were grown by Senegambian (Figure 4c).

Different uses of corn

The study revealed that corn grown in Benin is currently produced for several uses. Producers from all departments primarily produce for family consumption followed by trade view. Thus, 94.8% of the producers mainly produce corn for grains consumption. Also, it appears that 59.7% of the farmers sell their production and about 4.3% of producers use some organs in herbal medicine (Figure 5a). Some vegetative parts of the maize plant are used to treat certain sicknesses particularly in the departments of Donga, Atacora, Alibori and Ouémé with respective proportions of about 19, 17, 16 and 8% (Figure 5b). All ethnic groups produce maize mainly for their own consumption. But among the various ethnic

groups, Gurs ethnic group constitutes the group which sold most corn (up 76.4%). The Gurs and Senegambians use certain parts of corn plant in herbal treatments in the respective proportions of 9.7 and 7.1% against 0.9% for the producers of the Kwa ethnic group (Figure 5c).

Constraints to maize production

Corn producers are confronted to various constraints such as farming techniques constraints (decrease of soil fertility, culture still manual over wide areas, etc), harvests conservation, pests' attacks and climate changes. About 53.2% of producers referred to problems related to agricultural techniques followed by pest attacks (40.3%), decline in rainfall (38.6%) and finally problems related to harvest conservation (32.6%). Meanwhile, 10.7% of the investigated producers said that they had no constraints in maize production (Figure 6a).

Constraints analysis based on departments reveals that



Figure 3. Photograph showing the diversity of the color of corn cobs. **a:** white cob; **b:** yellow cob; **c:** red cob; **d:** multicolor cob.

all problems are related to cultivation techniques in the departments of Donga and Atacora. In Couffo, the constraints related to cultivation techniques are mentioned by 2.6% of the investigated population. The Plateau producers are most often confronted to problems related to the crops conservation (88.9%) followed by Donga farmers (81.3%). However, the producers of the Zou department said that they had no problem in crop preservation. The producers of the Atlantic department have evoked more parasitic attacks related problems (93.8%) followed by Plateau producers (88.9%). As for the problems related to the decline in rainfall, farmers in Atlantic (75%) followed by Donga producers (68.8%) reported to be confronted with this problem. However, producers of Zou (4.8%) and Collines (4.3%) are the least affected by this problem (Figure 6b).

Constraints analysis based on ethnic group reveals that ethnic groups Yoruboids (81%) and Gur (77.8%) evoked the constraints related to the worst quality of cultivation techniques. Regarding conservation constraints, 34.7% of Gurs and 34.8% of Kwa listed these constraints against 25 and 23.8% respectively for Senegambians and Yoruboids. The pest attacks and problems related to the decline in rainfall are much observed among the Senegambian (67.9%), followed by Gur (53.6%) and least underlined Yoruboid (19%) (Figure 6c).

Storage method of corn crops

Various traditional preservation methods are adopted by corn producers such as preserving crops as cobs

(37.3%) in the granaries and stores, as grains without (21.5%) and with (18.9%) chemical. The least used method is the regular drying crops with a rate of 1.7% whereas 21.5% do not store their harvest (Figure 7a).

The results of the Correspondence Factorial Analysis (CFA) performed on the data related to preservation methods for corn compared to departments are summarized in Figure 7b. Thus, in the first dial noted was an adoption of the observed grain and grain + chemicals conservation method in Ouémé, Plateau, Atlantic and Donga. In the second dial, according to the cob conservation respect it was observed a strong correlation with Atacora and Collines departments. The last dial shows that no conservation of crops is observed in the Couffo department.

Considering the ethnic groups, our data displays that 40.2% of Kwa sell directly their corn harvest while most of Senegambian (89.3%) stored their crops (Figure 7c). The conservation as grain is mostly used by Yoruboid (33.3%) followed by Gur (31.9%) and Senegambians (10.7%). The Kwa group (25%) used more chemical conservatives followed by Gur (16.7%) and Senegambians (3.6%). The regular drying method is used by Kwa (3.6%).

Method of varieties preservation

Several methods of preservation varieties have prevented the loss of the diversity of our local cultivars. Figure 8 provides information about the methods used by corn farmers to keep their varieties. Generally, we note

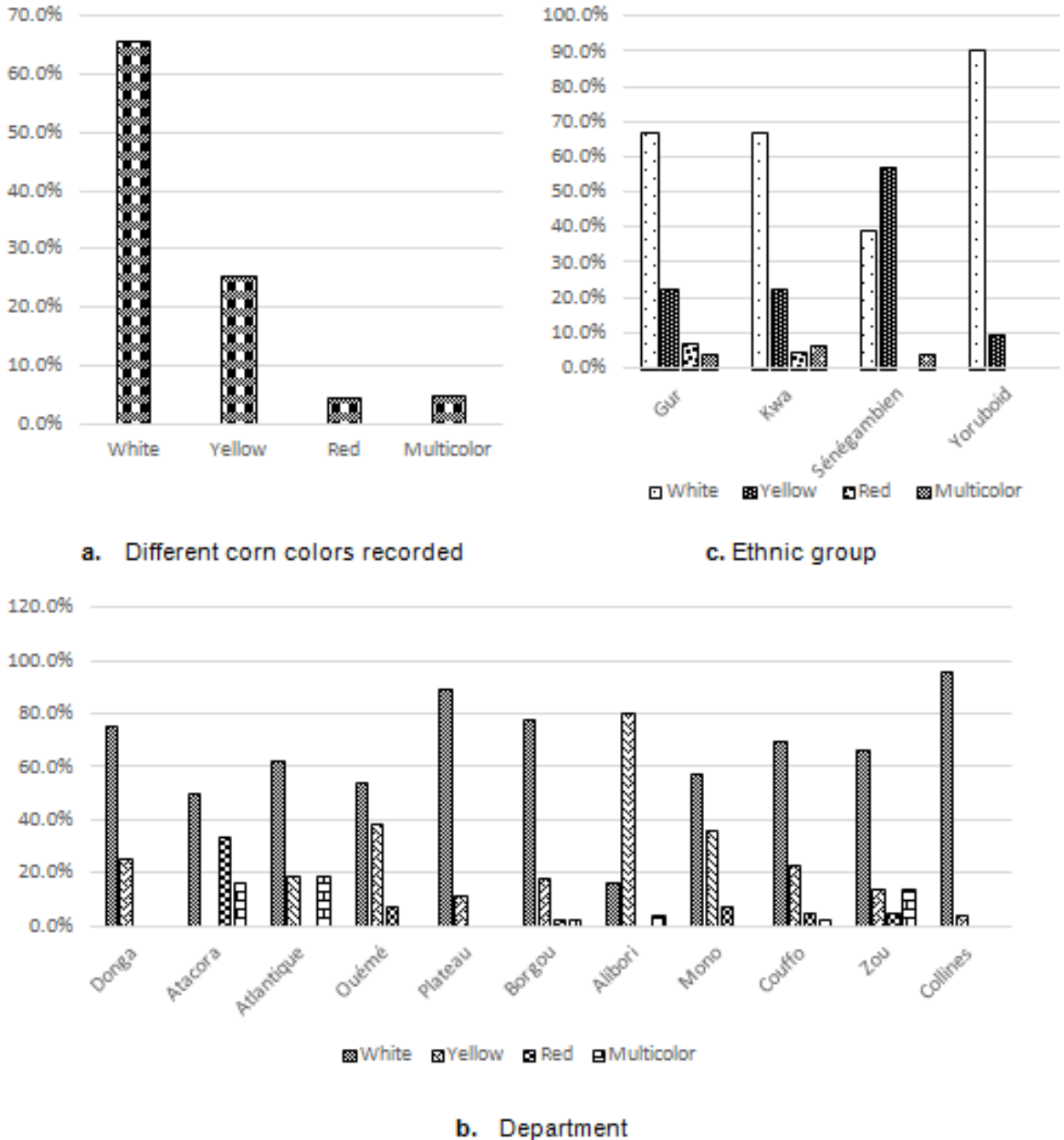
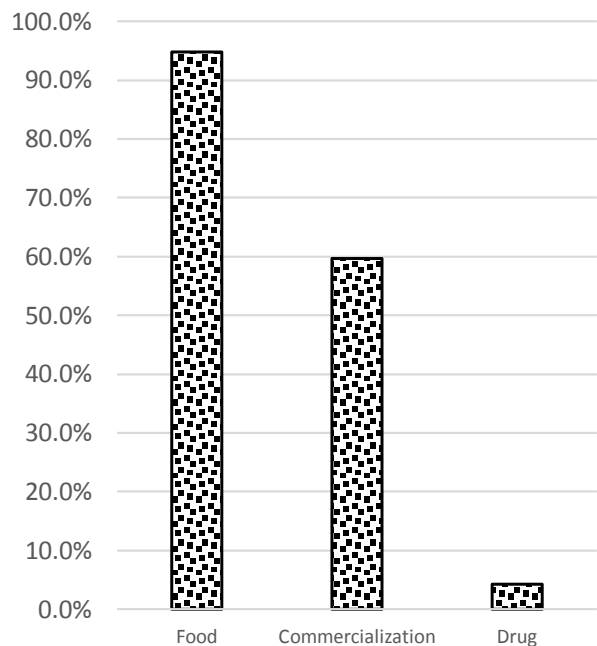


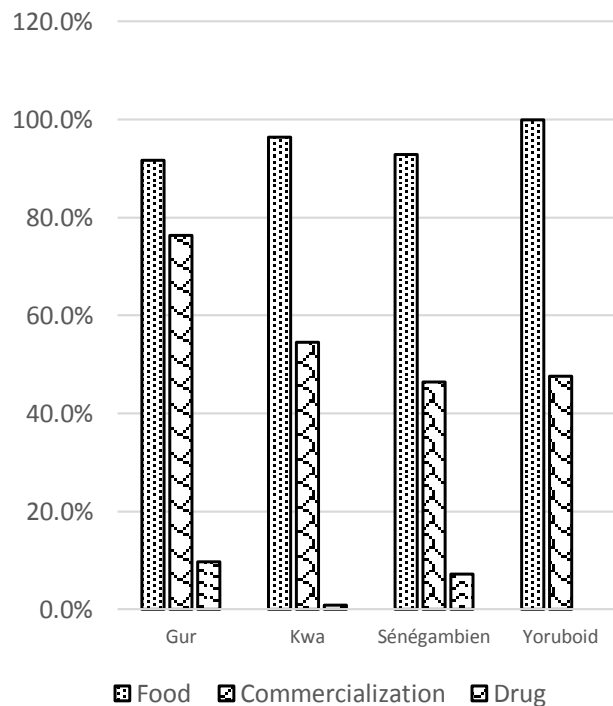
Figure 4. General presentation of corn colors cultivated in Benin according to department and ethnic group.

that 57.9% of producers make mass selection. Only 5.2% proceed to seed renewal; 2.6% proceed to isolation plots in aim to avoid mixtures of varieties and 35.6% observed no measure for the preservation of varieties (Figure 8a). Figure 8b shows the results of the Correspondence Factorial Analysis (CFA) performed on the data related to

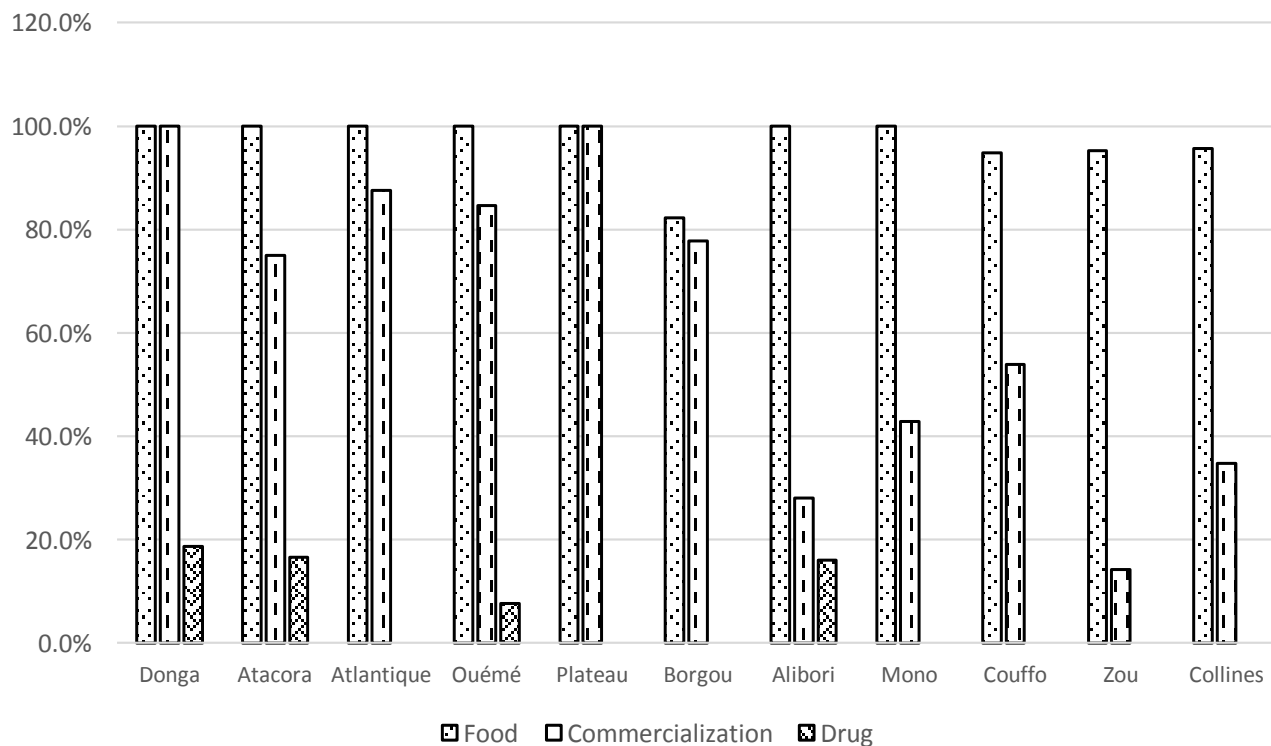
the preservation of varieties modes compared to the departments. The first two dials show that cob choice in middle field method is used almost in all departments except Donga. According to dial 3 the method of isolation on fields, varieties renewal and curvature sowing are observed in the department of Donga. The fourth dial



a. Uses of corn

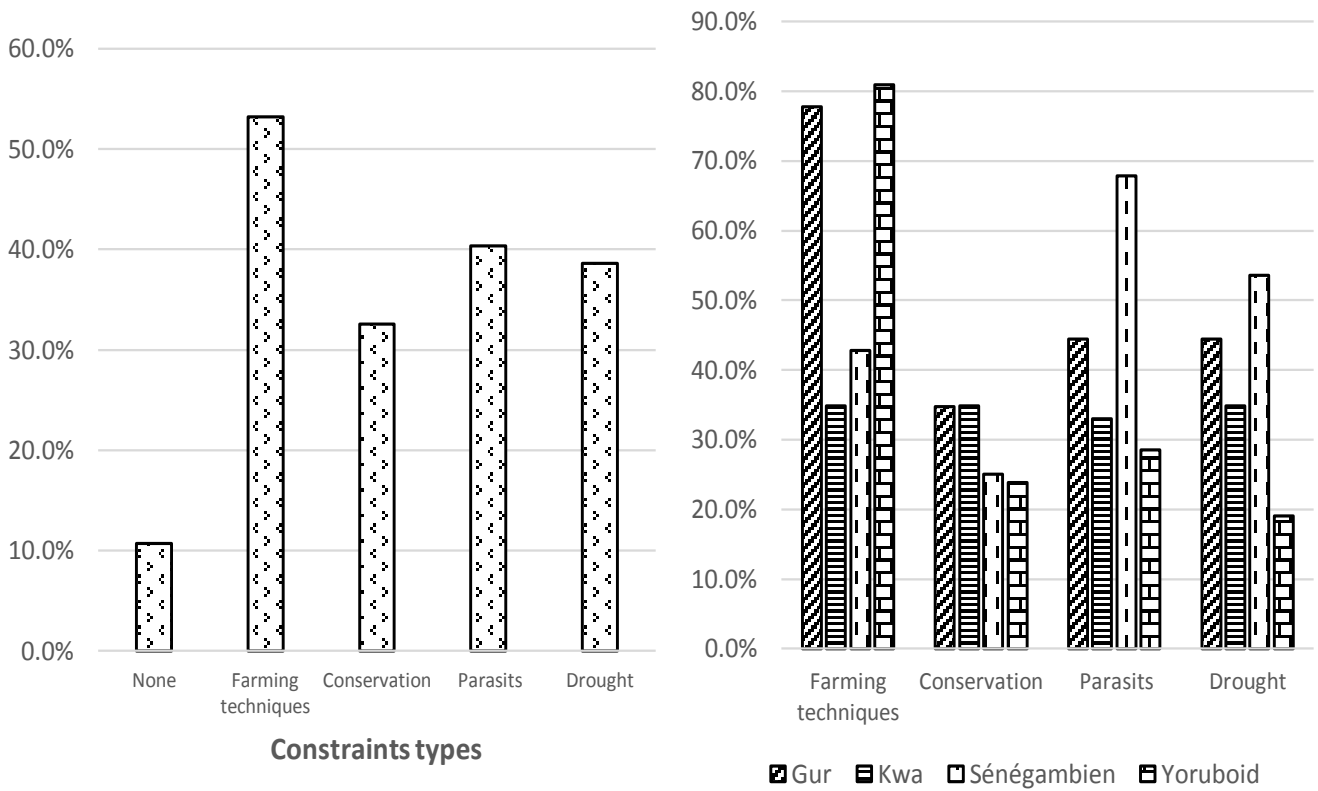


c. Ethnic groups



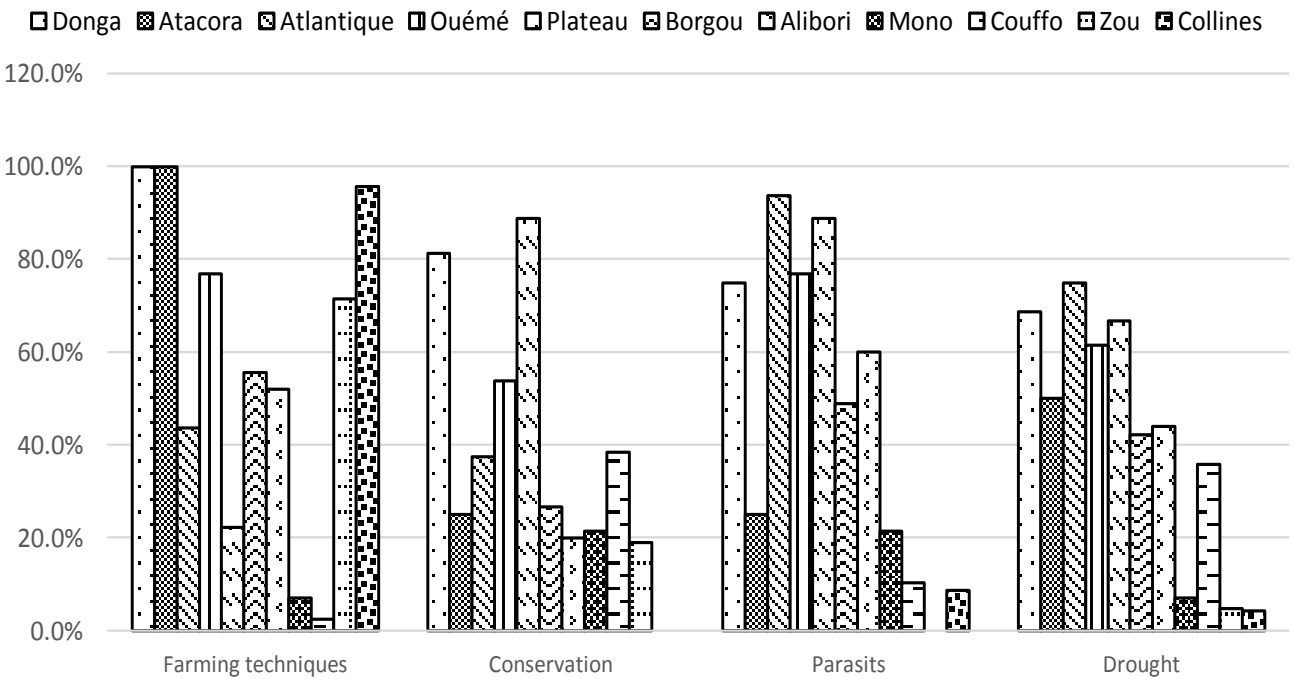
b. Departments

Figure 5. General insight of corn products uses by departments and according ethnic groups.



a. General constraints

c. ethnic groups



b. Departments

Figure 6. General glimpse of constraints related to corn production based on departments and ethnic groups.

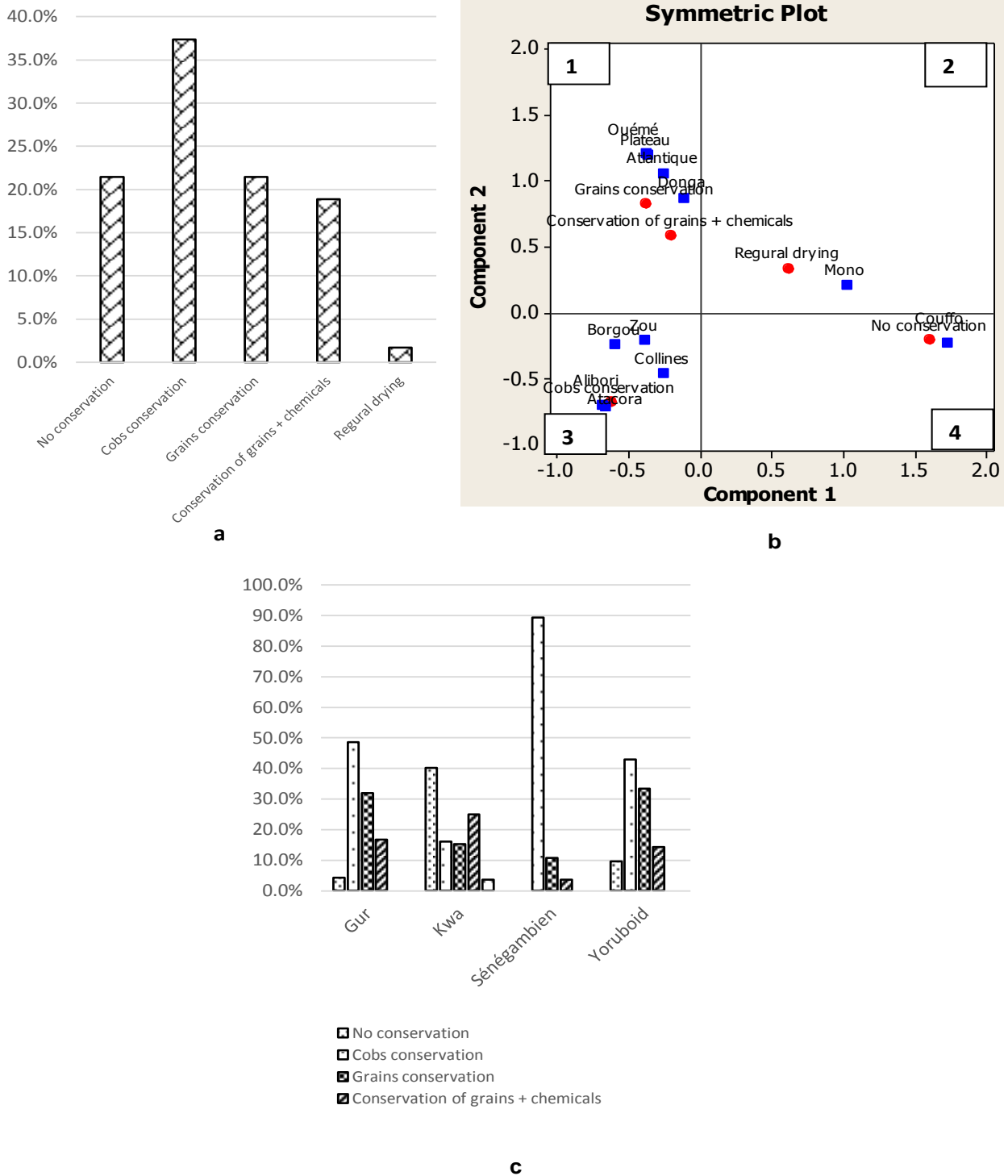


Figure 7. General corn conservation techniques after harvests. a. corn harvest; b. CFA showing the correlation of axes 1 and 2 according to departments' storage method of corns. c. ethnic group.

showed that some producers of Atacora, Mono and Couffo kept no varieties preservation measure.

The most used method by producers is mass selection which is a method used by all ethnic groups with a predominance observed by 96.4% of Senegambian. The

plot isolation method is employed exclusively by the Gur group with 8.3%. The renewal of seeds is essentially seen in the group of Gur (9.7%) and Kwa (4.5%). However, 50.9% of Kwa producers keep no measure for preservation followed by Yoruboid (28.6%) and Gur (27.8%) (Figure 8c).

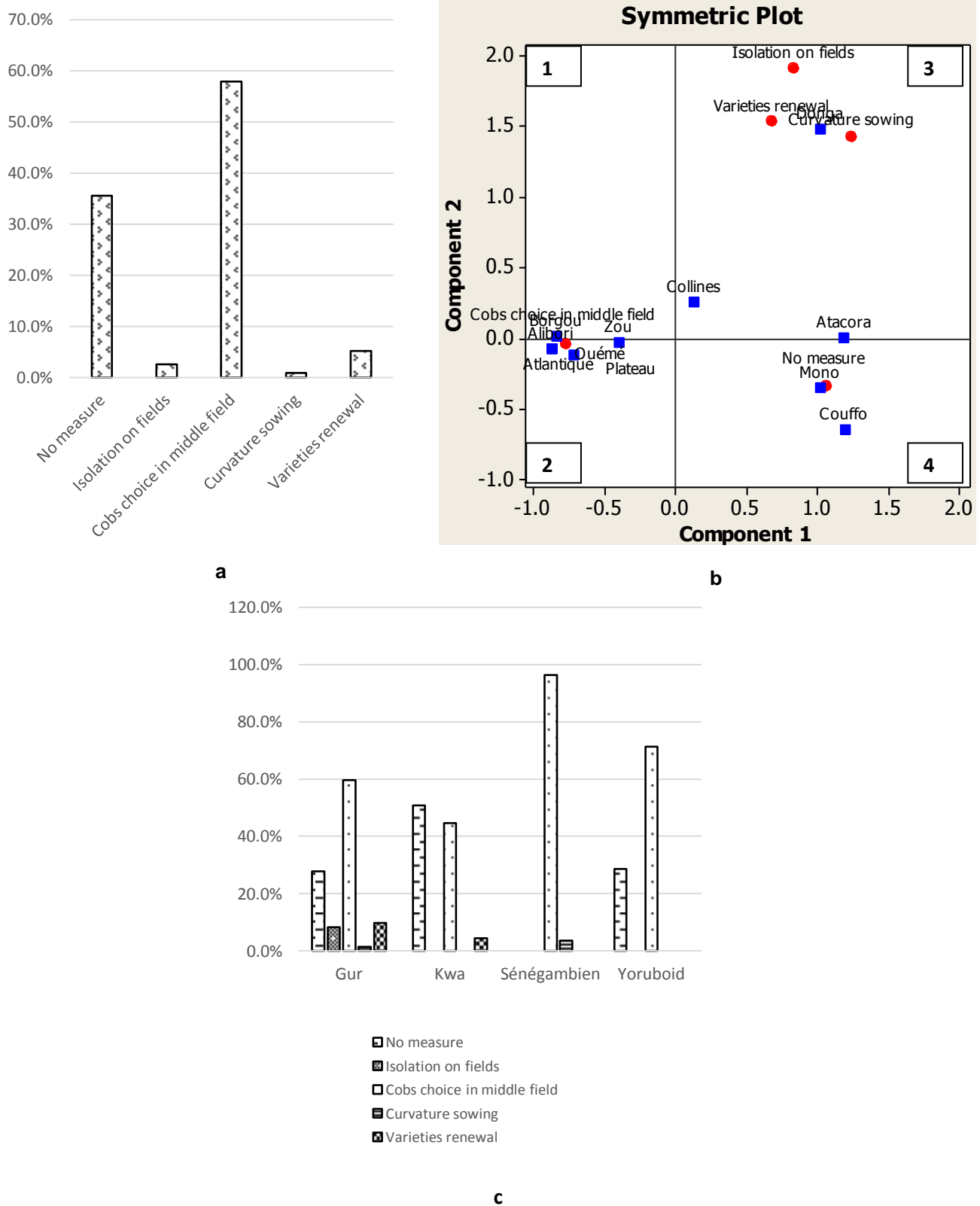


Figure 8. Global aspect of corn crops preservation method according to departments and ethnic groups. a. Preservation method. b. CFA showing the correlation of axes 1 and 2 according the method of corn varieties preservation by department. c. ethnic groups.

DISCUSSION

Local names of maize in Benin

The Republic of Benin have favorable conditions for the development of several crops like cereals, including maize (*Zea mays*) that ranked first. Cereal is the first available in the agricultural calendar and helps to cross the end of the lean season. Corn presents also the advantage to be harvested from the early milk stage and also provides the first income through the commercialization of fresh ears intended to be grilled or boiled (Bricas et al., 1994).

In Benin, corn has several names depending on the production department and ethnic groups. Thus, we recorded 19 different appellations of corn regarding local languages spoken in Benin. In some ethnic groups, it is common to have variations about the naming of certain things according to their geographic location. For example, in Bariba, corn is commonly called "Gbèrènou" by the people met in Borgou while in Alibori the term "Mandé" is the most frequent. Moreover, you can have intra-language differences due to pronunciation variations. In this case, we find that the word's root is retained like in the case of 'gbaa', 'Gbadé' and 'Gbayé' in Kotafon or 'Kokoli' and 'Kokoliri' in Fulani. Nevertheless, in some cases, it is recorded that a local names ("WamLan") common to several languages (Lokpa and Kabyè). Also, in Idatcha and Tchabè languages, corn is called "Gbado". This observation can be explained not only by the fact that several languages have the same origin but also because of the linguistic brew due to the ethnic groups' neighborhood.

Maize cultivars status

These are in one hand local cultivars adapted and cultivated by farmers in an environment for a long time and in other hand improved varieties popularized by the agricultural research institutes. However, the local corn cultivars are the most cultivated in Benin according to our investigation data. This find confirm those of Aly et al. (2007) when he reported that most of Benin farmers are attached to traditional varieties. Indeed, despite the introduction of improved high yielding varieties, most of farmers have always remained attached to local cultivars probably because of their organoleptic and/or socioeconomic preferences. Thus, despite their superior agronomic performance, improved maize varieties are very few adopted (Tchamo 1993). Also, the major part of farmers retain local cultivars inherited from their ancestors in order to maintain the family's traditional farming methods. In addition, as local cultivars seeds or not sold in contrary to improved one, some of farmers continues with their traditional practices. The provision of local cultivars' seeds is currently achieved by old

practices such lent, exchange and / or provision. This situation continues because of a lack of national regulations or legislation for seeds/plants production and distribution in Benin.

The rate of use of improved varieties varies according to the department and ethnic groups. Considering the departments, Atlantic and Alibori departments mostly cultivated local cultivars. Despite this strong preference for local cultivars, it should be noted that these departments have high national performances of corn. Indeed, according to a report by the National Support Office to farm incomes (MAEP 2010), the departments of Borgou-Alibori nationally rank second as the best producer of maize up to 27% followed by Atlantic-Littoral departments (14%). These high yields may be explained by the availability of arable soil in these departments, particularly in Borgou-Alibori where the manpower and animal traction are available for field work. In the contrary, improved varieties are mostly grown in Donga because, according to the farmers of this department, the improved varieties are flourier, more resistant to drought and pests attacks, have a short cycle and have good yield. However, despite this strong adoption of improved varieties, the Atacora and Donga departments are the last in terms of maize production from 2000 to 2009 with a national rate of 8% (MAEP, 2010) maybe because of the presence of mountain ranges encountered in these departments, reducing arable land.

Regarding the ethnic group, Senegambians are cultivating more local cultivars while the Gurs ethnic group grows much more improved varieties. The strong attachment of Senegambians to local cultivars may be explained by the fact that Senegambians are mainly nomadic Fulani who produce only for their livestock feed and their own consumption. Pastoralism and livestock cattle are, in fact intimately associated with "Fulani" being and the Fulani herders make agriculture to be able to eat without having to destock their herd (Ciavolella, 2012). Thus, for better conservation of local maize cultivars, the Senegambians could be the most appropriate ethnic group as he reported to be the holders of endangered varieties (Baco et al., 2011).

Varietal diversity of maize depending on the color

From the four different colors (white, yellow, red and multicolor) of corn grown in Benin, the white one is the most grown and preferred by consumers. Traditionally, the white cultivars are mainly produced for human consumption probably because of their flour (Baco et al., 2011).

The yellow varieties colors are mostly cultivated in the department of Alibori by Senegambian ethnic group. These yellow varieties are often used in this part of the country for its taste, in lean periods and in poultry feed. Nevertheless, in the northern part of the country, we do

not notice specificity in the adoption of any variety because it is reported that corn usually grown in the south and center (Ouémé, Mono, Atlantique and Zou) (Yallou, 1994). The observation of multicolor varieties may be due to an inter-pollination between different varieties grown near to each other.

Different uses of corn

In Benin, maize production is mainly intended for human consumption followed by commercialization and a small proportion is used for herbal medicine. This state may be due to the fact that production is still under artisanal way allowing to limit the sown areas. Thus, the subsistence farming still appears in certain regions such as Benin and Cameroon like the main outlet for the maize production (Bricas et al., 1994). Although the African maize food uses are relatively limited (Marathée, 1994), it is consumed in Benin in various forms of food (roasted corn, boiled corn, paste, akassa and drinks, etc). A high proportion of producers, particularly in four departments (Donga, Atacora, Alibori and Ouémé) report the use some organs of corn plant in the treatment of several illnesses. Thus, for example, corn cob (good fuel) is used single and/or in combination with other plants for the treatment of many pathologies such as malaria, knee and rib pains. The drug using the organs of this cereal can be prepared as tea infusion. This organ is also reported to be used in Europe for drying corn kernels in seed production and in Africa to make charcoal. Other industries take part of the roundup by producing granules or flour incorporated into adhesives, plastics, abrasives, cosmetics and pharmaceuticals (Gnis, 2013).

Constraints to maize production

Maize production in Benin is essentially confronted to problems of climatic and pest attacks. Indeed, termite attacks, lack of rain and decrease of soil fertility are frequently reported factors that discourage producer and let them forsake maize farming. Moreover, the non-mechanization of agriculture and the low interest of young people for farming are additional constraints to maize production in Benin. Once after production, the harvest is frequently reported to be attack by weevils and other pests. However, these constraints vary slightly from one department to another. Thus, while the producers met in Zou declare not to be exposed to any constraint, the producers of the departments of Donga and Atacora evoked problems of farming techniques. The problems associated with the harvest conservation are the most cited in the departments of Plateau and Donga. The departments of Atlantic and Plateau are mainly exposed to pests' attacks. The climate changes effects are mostly mentioned by producers of Atlantic and Donga.

Regarding ethnic groups, we saw that Yoruboids and Gur ethnic groups reported highly the influenced by growing techniques. The constraints related to harvest conservation are reported by Gurs and Kwa followed by Senegambians and Yorouboids. The parasite attacks and drought-related problems are much evoked by Senegambians.

Storage method of corn crops

Among the traditional preservation techniques in Benin, we find that the crops are often stored as ears in granaries and/or stores. This method is the most observed in the departments of Centre and North of Benin by Senegambians. This situation can be explained by the fact that in the northern and central areas, crops are dried directly in the field up favoring harvesting cobs de-husk that is not the case in the southern part. Indeed, the northern and central Benin climatic conditions offer drying up the field opportunities favoring harvesting de-husked corn which case is not the same in the southern part. In the West African region, conservation as cobs is reported by CEEMAT (1988) either in ventilated attics (Togo) or as clusters of ears in trees (Ivory Coast) or dried on "bandas" (Cameroon). Thus, we saw that the traditional storage structures are made from local materials (earth, woven plant fibers, etc) and store more often ears with and without husk.

Besides this method of preservation by ears, we recorded harvest conservation in the form of grains without and/or with chemical preservatives. This method relies on keeping in bulk maize grain in metal silos, containers, bags and even in cribs (south Benin). This form of conservation is the most observed with Yoruboids and Gur because it optimizes the reduction of moisture content (Marathée, 1994) and therefore increases the shelf life. Indeed, proper drying and storage limit losses due to insects and rodents depreciation and avoid the development of mycotoxins. For this form of grain storage, bags and store storages are the most frequently chosen because they allow the use of traditional structures (CEEMAT, 1988). Meanwhile, in Africa although the storage in bulk is expanded, there are existing materials (metal silos) economically less profitable than traditional structures for small quantities (CEEMAT, 1988). We note that the conservation in bulk is enhanced by the use of natural (ash, neem leaves) or synthesized (sofa grain) product in Atlantic department followed by Plateau and Ouémé specifically by the producers of kwa ethnic group. It seems being a good method because chemical additives are effective when used against post-harvest pests such as *Sitophilus zeamais* (Kossou, 1989). Also, although more difficult, regular crops drying method is used by kwa producers as heritage. Finally, almost one quarter of surveyed producers, especially in the southern, do not bother to

store their crops and therefore sell them directly after harvest.

Method of varieties preservation

Several methods are used by farmers to preserve Benin local maize cultivars diversity. The selection of best ears (nice and big) at the middle of the farm before harvest was the most recorded. Thus, the selected ears, are cultivated taking care to prevent their mix with other varieties including improves. This practice is applied in most of departments and helps to maintain genetic purity of traditional varieties and species. As part of the above method, we noticed improved varieties seed renewal method technical farming structures for one to four years (1 to 4 years) by the producers of Donga, Collines, Mono and Zou. Seed renewal was recorded mainly with Gur and Kwa ethnic groups. Due to the availability, we noted the parcels isolation technique to ensure the purity of varieties in the departments of Donga, Atacora and Borgou by Gur ethnic group.

CONCLUSION

The inventory of corn accessions grown in Benin shows an abundance of cultivars. Farmer developed local and indigenous practiced for improving existing maize varieties production and conservation. Thus 19 different names are given to corn depending on the local languages spoken in Benin. Four color of local and improved varieties are meet and mainly produced for own consumption, commercialization and herbal cures. But farming techniques, harvest conservation (ears or grains), parasites and drought-related problems are essentially the major constraints to maize production. The varieties are maintained traditionally, with the aim to avoid variety mixtures, by mass selection, renewal of seeds and isolation of fields' methods. This study provides a data base of the biodiversity of corn local varieties cultivated in Benin.

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