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Pigeonpea [(*Cajanus cajan* (L.) Millsp.)] production system, farmers' preferred traits and implications for variety development and introduction in Benin

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Abstract

Background: The success of crop varieties introduction is tightly linked to the uses, biophysical conditions, the cropping systems in which the crop is integrated and farmers' and consumers' preferences. In Benin, however, pigeonpea production systems including the cropping systems, marketing, utilizations and preferences have received little attention. This study aimed at analyzing farmers' practices and constraints related to pigeonpea production as well as identifying farmers' preferred traits in pigeonpea.

Methods: The study was conducted in three pigeonpea-growing agroecological zones in Benin. Participatory rural appraisal tools including individual interview ($n = 302$) and group discussion were used to collect information on production system, constraints and preferred traits. Fisher's exact test was used to assess the relationship between crop associated with pigeonpea and the growing areas. Based on preferred traits, villages were clustered using UPGMA.

Results: Pigeonpea is predominantly grown by men. Approximately 98% of the pigeonpea growers associated pigeonpea with other crops, while 2% of them grew the crop in pure stand. Pigeonpea grown in association with maize (48.7%) was the most encountered cropping system. The type of crops associated with pigeonpea depended on the growing area ($P < 0.001$), and a high diversity in crops combination was observed in the Department of Couffo. Lack of improved varieties, low productivity and lack of quality seed were major factors constraining pigeonpea production. The pigeonpea seed system was essentially informal with self-saved seed (79%), purchase from fellow farmers or from local markets (12%) and gift/exchange (9%) as seeds sources. Farmers' preferences traits varied across pigeonpea-growing area, but overall, high yielding, early maturing, and resistance to pod borers were the main reported preferred traits.

Conclusion: Our results confirm the importance of pigeonpea both in the cropping systems and in contributing to ensure food security in the growing areas in Benin. Farmers' varietal preferences were identified. This information is important for designing appropriate strategies for sustainable pigeonpea production. Insight gained into farmers' preferred traits in pigeonpea varieties will also help in the choice of varieties or advanced breeding materials to be integrated into participatory varietal selection programs in order to improve productivity of the crop in Benin.

Keywords: Cropping systems, Farmers' preferences, Production constraints, Seed system

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Background

Pigeonpea [*Cajanus cajan* (L.) Millspaugh] is the sixth most important legume crop in the world [1]. Worldwide, pigeonpea production averaged 4.89 million tons in 2014 [1]. India and Myanmar are the major producers (83%) ahead of Malawi, Tanzania, Kenya and Uganda as major producers in Africa (14%) [1]. In West Africa, pigeonpea is a minor crop, but it plays a key role in the subsistence of smallholders in Benin, Nigeria and Ghana [2–5]. Pigeonpea seeds are highly nutritious [6]. The mature seeds contain 18.8% protein, 53% starch, 2.3% fat, 6.6% crude fiber and 250.3 mg 100 g^{-1} minerals [7]. As a perennial shrub, pigeonpea has many advantages over annual legumes in that several harvests are possible and the capacity to contribute to enhance soil fertility is much higher [8]. Pigeonpea has high tolerance to drought stresses, high biomass productivity, which is mainly used as fodder, and provides the most nutrient and moisture contributions to the soil [9, 10]. With climate variability and the occurrence of prolonged drought, pigeonpea offers resilience to cropping systems and its cultivation is expected to expand to new areas [11]. Moreover, pigeonpea has a huge untapped potential for improvement both in quantity and in quality of production in Africa [10].

In terms of production quantity, pigeonpea is the fifth legume after cowpea (*Vigna unguiculata*), Bambara groundnut (*Voandzeia subterranea*), soybean (*Glycine max*) and groundnut (*Arachis hypogaea*) in Benin. The annual planted area on average amounts to 4059 ha with an average production of 2799 tons [12]. Pigeonpea is an important source of income for rural households [2]. The crop is mainly grown in the southern and central regions of the country and is primarily used for human consumption [3]. Pigeonpea is integrated in the cropping systems mainly in alley cropping for soil fertility restoration [13, 14] and for pest management [15].

Pigeonpea production systems and farmers' varietal preferences have been well documented in several countries including India, Tanzania, Uganda, Kenya, Nigeria and Ghana [4, 16–19]. These studies suggest that pigeonpea cropping systems and farmers' preferences vary across growing areas. In Benin, however, pigeonpea production systems and farmers' preferences traits have received little attention [2]. This knowledge gap may limit the efficiency of interventions seeking to promote pigeonpea production in the country. Identification of farmers' preferences traits is useful for breeders in developing preferred varieties and for extension agents in appropriate choice of varieties to be popularized [20–22]. In addition, knowledge on production systems and the rationale driving farmers' practices are key requirements for guiding successful variety introduction. This study aimed at (1) identifying farmers' practices and constraints related to pigeonpea production in Benin and (2) identifying farmers' preference traits in pigeonpea.

Methods

Study area

The major pigeonpea-growing areas were identified based on information collected from extension agents of the Ministry of Agriculture [Ministère de l'Agriculture, de l'Elevage, de la Pêche (MAEP)]. Major pigeonpea-growing areas are located in three agroecological zones (V, VI and VII) in southern (Departments of Plateau, Couffo and Zou) and center (Department of Collines) Benin (Fig. 1; Table 1). In these areas, maize, cassava, yam, cowpea and vegetables (tomato, pepper) are the major crops [12]. Within each agroecological zone, major pigeonpea-growing municipalities and villages were identified jointly with extension agents based on pigeonpea production [3]. Twenty villages were selected (Table 2).

Focus group discussion, sampling and questionnaire administration

Data were collected from March to April 2015. Prior to data collection, local authorities (head of villages) were contacted by the researcher team, and the objective of the study was explained to them. They helped in the identification of pigeonpea growers who were used as entry point for focus group discussion and the sampling for in-depth study.

A focus group discussion, involving 9–13 pigeonpea growers, including female, male, youth and adults, was carried out in each village. The focus group discussions provided an insight into the various pigeonpea-based cropping systems, cultivation practices and utilization. During the group discussion, farmers were asked to list their major pigeonpea varieties preference criteria. This study did not intend to rank farmers' preference criteria but to identify the combination of most important traits farmers seek in a variety at village level. Information collected during the focus group discussions was used to design a questionnaire for in-depth study. The questionnaire was subdivided into the following sections:

1. Sociodemographic information (gender, age, available cultivable land, allocated area to pigeonpea, experience in pigeonpea production);
2. Cropping system: cultivation operations, crops associated with pigeonpea, production constraints and coping strategies;
3. Gender in pigeonpea production and commercialization systems;
4. Post-harvest management of pigeonpea grains and seed systems.

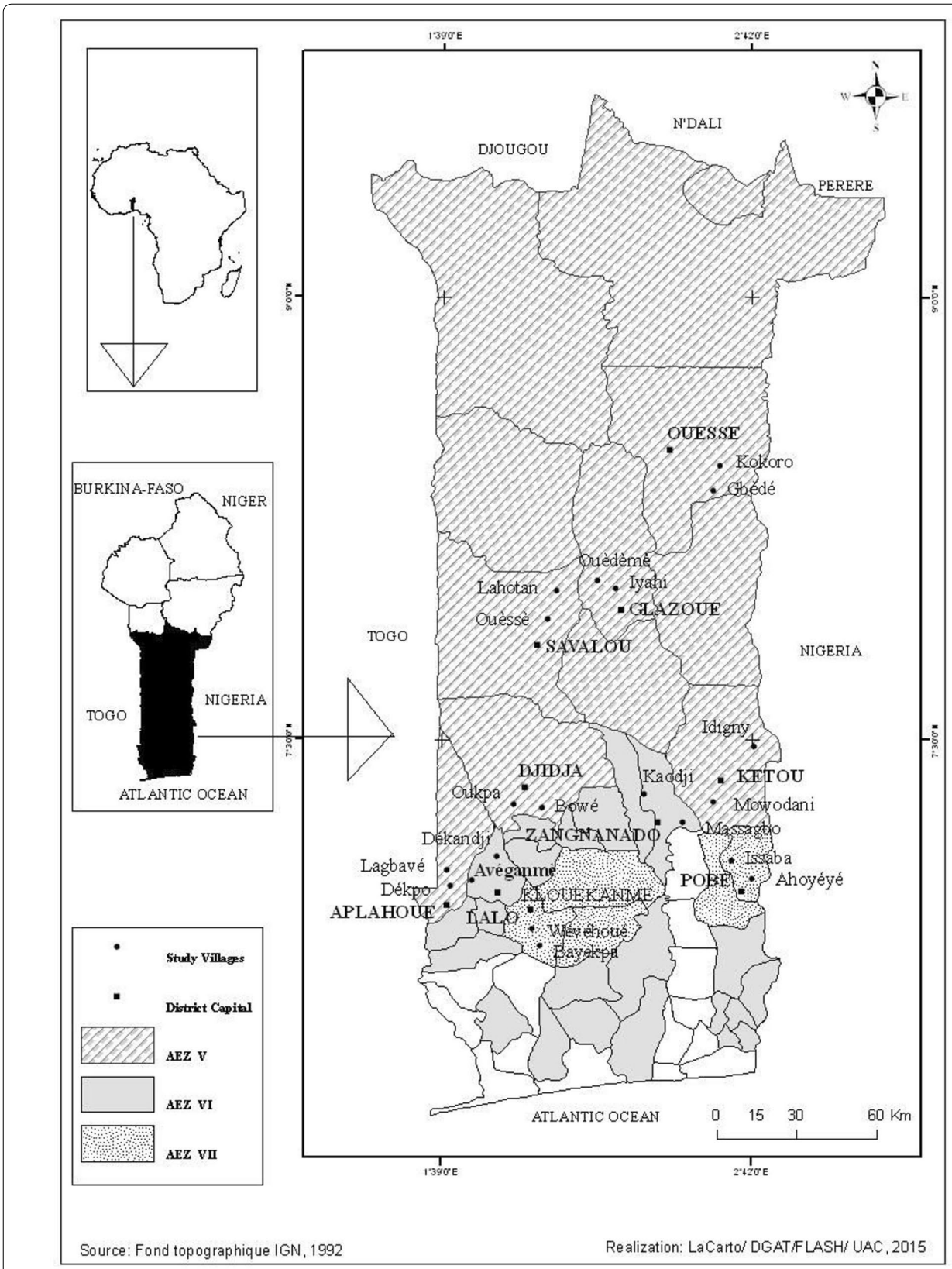

Fig. 1 Map of the surveyed areas

Table 1 Biophysical characteristics of the surveyed areas. Adapted from [23, 24]

Agroecological zones and selected municipalities	Climate	Main soil type	Range of average annual rainfall
North Zone V: Ouèssè, Glazoué, Savalou, Djidja	Sudano-guinean with unimodal rainfall regime	Ferruginous	1100–1300 mm
South Zone V: Ketou, and Aplahoué	Guinean with bimodal rainfall regime	Ferruginous	1100–1300 mm
Zone VI : Klouékanmey and Zagnanado	Guinean with bimodal rainfall regime	Ferruginous	800–1400 mm
Zone VII: Lalo and Pobè	Guinean two bimodal rainfall regime	Vertisol	1100–11,400 mm

Table 2 Samples distribution

Departments	Municipalities	Villages	Sample size
Zou	Zagnanado	Kaodji, Massagba	33
	Djidja	Bowé, Oukpa	30
Couffo	Lalo	Bayékpa, Wévéhoué	31
	Aplahoué	Dékpo-centre, Lagbavé	32
	Klouékanmey	Dékandji, Avéganmè	34
Plateau	Pobè	Issaba, Ahoyéyé	30
	Kétou	Idigny, Mowodani	30
Collines	Savalou	Ouèssè, Lahotan	25
	Ouèssè	Gbede, Kokoro	28
	Glazoué	Ouèdèdmè, Magoumi	29

For the in-depth study, pigeonpea growers were sampled using the snowball technique. This sampling technique consists in widening the sample starting from a respondent who helps to find other potential respondents [25]. The interest was to interview only farmers involved in pigeonpea cultivation. Using this technique, 302 pigeonpea growers were reached in 20 villages (Table 2). In each village, sample size was obtained based on saturation of information. Data saturation was considered reached when new respondents provided no additional information [26, 27].

Data analysis

Respondents were asked to make a hierarchical ranking of encountered constraints. In each Department, the major constraints were presented. Descriptive statistics (frequencies, means and standard error of mean) were calculated for quantitative data. Crops associated with pigeonpea were recorded per farmer. Fisher's exact test was used to assess whether the different crops combination with pigeonpea were dependent on the growing areas (Department) since the frequency of some cells in the contingency table was >5 [28]. The different pigeonpea variety preference criteria mentioned by farmers during the discussion group were recorded. In each village, a preferred trait was assigned the value 1 if mentioned and 0 if not mentioned. A contingency table was then obtained by considering villages as individuals and preferences criteria as variables. A clustering analysis using Unweighted Pair Group Method with Arithmetic Mean (UPGMA) based on Jaccard distance was performed to reveal similarity and dissimilarity among surveyed villages based on the preference criteria. The analysis was performed in R version 3.2.5 [29].

Results

Sociodemographic characteristics of the respondents

Three hundred and two (302) pigeonpea growers (Table 2), 62% of which were men, were interviewed. The respondents were 42 ± 1 years old on average. Pigeonpea growers had been cultivating the crop averagely for about 17 years with 59% having more than 15 years of experience in pigeonpea production. The average farm size per household was about 2.92 ± 0.15 ha of which about 1.24 ± 0.06 ha on average was allocated to pigeonpea associated with other crops (Table 3).

Pigeonpea-based cropping systems

Regardless of the pigeonpea-based cropping system and the growing areas, pigeonpea cultivation involved plowing, sowing, field maintenance (weeding), first harvesting, weeding and second harvesting (the following cropping season).

Farmers incorporated pigeonpea in various cropping systems. About 98% of the pigeonpea growers practiced intercropping, while only 2% of them grew pigeonpea in pure stand. There was no significant difference ($P > 0.05$) in the pigeonpea-based cropping systems across the various growing areas (Table 4). However, crops species associated with pigeonpea depended on the growing area ($P < 0.001$) (Table 4). For example, in the Departments of

Table 3 Sociodemographic characteristics of pigeonpea growers

Sociodemographic variables	Minimum	Maximum	Mean ± SD
Age of respondents (years)	18	82	42 ± 1
Cultivated area (ha)	0.25	20	2.92 ± 0.15
Pigeonpea harvested area (ha)	0.04	6	1.24 ± 0.06
Experience in pigeonpea production (years)	1	50	17 ± 1

Table 4 Proportion of farmers practicing various pigeonpea-based cropping systems (number of respondents in brackets)

Cropping systems	Zou ($n = 63$)	Couffo ($n = 97$)	Plateau ($n = 60$)	Collines ($n = 82$)	*P*
Cropping system					
Pure stand	0	0	3.3 (2)	3.7 (3)	0.059
Crop association	100 (63)	100 (97)	96.7 (58)	96.3 (70)	
Associated crops					
Maize	69.8 (44)	0	50 (30)	89 (73)	<0.001
Legume	1.6 (1)	0	0	0	
Maize, cassava/yam	4.8 (3)	0	21.7 (13)	4.9 (4)	
Maize, legumes	(22.2) 14	10.3 (10)	8.3 (5)	2.4 (2)	
Maize, vegetables	0	0	13.3 (8)	0	
Maize, legumes, cassava	1.6 (1)	43.3 (42)	0	0	
Maize, legumes, vegetables	0	6.2 (6)	3.3 (2)	0	
Maize, cassava, vegetables	0	2.1 (2)	0	0	
Maize, banana, cassava	0	3.1 (3)	0	0	
Maize, banana, vegetables	0	3.1 (3)	0	0	
Maize, legumes, cassava, vegetables	0	23.7 (23)	0	0	
Maize, legumes, banana	0	3.1 (3)	0	0	
Maize, legumes, vegetables	0	3.1 (3)	0	0	

P probability of Fisher's exact test, *n* number of respondents

Plateau, Collines and Zou, pigeonpea was predominantly associated with maize either on the same ridge or on different ridges. When the association was done on the same ridge, farmers generally adopted a distance of about on meter between maize plant and pigeonpea plant.

Gender role in pigeonpea value chain

Pigeonpea production and commercialization involved all the members of the household including men, women and children. However, the involvement of each member depended on the specific task to be performed (Table 5). The level of involvement was considered as the physical participation in the implementation the activities and/or in the mobilization of resources indispensable for the implementation of the activity. Thus, men were highly involved in decision affecting the production such as choice of variety to be cultivated, land allocation, land preparation and weeding while women were mostly involved in decisions related to the harvest and commercialization.

Table 5 Male and female level of involvement in pigeonpea production

Level of decision	Male	Female
Choice of variety	+++	++
Land allocation	+++	+
Land preparation (clearing, plowing)	+++	+
Weeding	+++	+
Harvesting and threshing	++	+++
Commercialization	++	+++

+ indicates the level of involvement

Post-harvest and seed system

Post-harvest handling

Harvest is usually performed from January to February. The harvest consists of picking the mature pods by hand. The harvested pods are then threshed on tarpaulin using sticks. The grains are dried and stored. Farmers used various structures including calabash gourds, cans and sacks to store and conserve pigeonpea grains. The storage period ranges from 1 to 12 months with an average of about 6 months after harvesting. Overall, 90% of the farmers did not use any conservation product (Fig. 2). However, in the Department of Plateau, 28% of the growers used kerosene and/or insecticides, while 12% of the respondents in the Department of Couffo used chemical insecticides mainly temephos [0,0′-(thiodi-4,1-phenylene) bis (0,0-dimethyl phosphorothioate] (Fig. 2). Two percent (2%) of the respondents in the Department of Plateau used indigenous methods such as pepper or ash that they mixed with seeds and then packed the mixture in cans or calabashes gourds (Fig. 2). No pigeonpea seeds conservation product was reported in Departments of Zou and Collines (Fig. 2). It is worth noting that farmers conserved their saved seeds mainly in cans and calabash gourds where seeds were less exposed to moisture and insects.

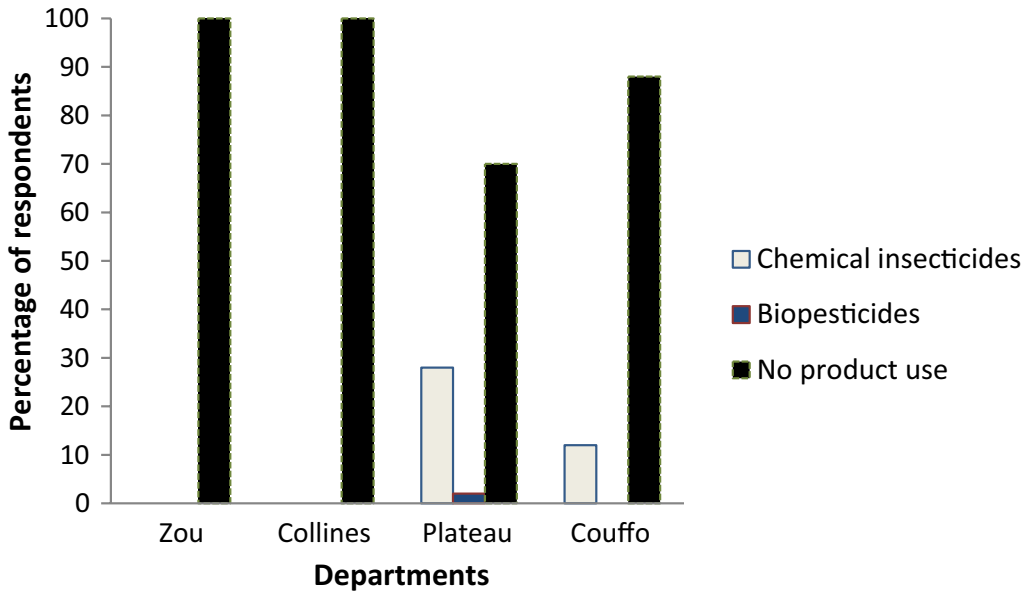

Fig. 2 Proportion of pigeonpea growers using various conservation products

Seed systems

Fifty-five (55%) and 45% of pigeonpea growers had purchased and obtained seeds as gift or heritage, respectively, to establish their first pigeonpea field. Once farmers started growing pigeonpea, 79% of them saved seed to plant the next season. Besides self-saved seeds, 12% of respondents purchased seed from fellow farmers in or outside the village and 9% of them received seeds as gift from friends, family members and extension services. Farmers' saved seeds were taken from the previous harvest (bulk seed after threshing). In the farmers saved seed system, after sowing, the remaining saved seeds were sold to fellow farmers or as grains for consumption (Fig. 3). Pigeonpea growers purchased seeds when they lost their production or their saved seed was not enough to plant the field or when they found a new with desirable traits.

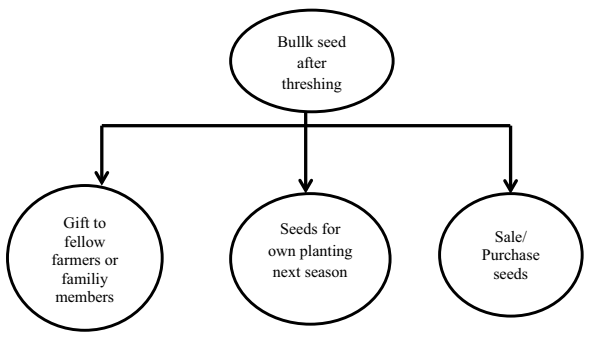

Fig. 3 Pigeonpea seed system

Factors constraining pigeonpea production

Pigeonpea production was constrained by several factors varying from one production area to another (Table 6). In the Department of Collines, difficulty to harvest pigeonpea pulses and high rainfall at flowering or pod setting stage were the major constraints limiting the production while in the Department of Zou, difficulty in pulses harvesting and threshing were the main challenge faced by farmers. High rainfall at flowering stage leading to flowers drop and lack of financial resources were ranked as the most important factors constraining pigeonpea production in the Department of Plateau. Non-availability of quality seeds and low yield were the two most important constraints reported in Couffo (Table 6). Facing the various constraints, farmers took actions such as hired labor, mutual aid to deal with lack of financial support and difficulty in pulse harvest, reuse of saved seeds to cope with difficulties related to access quality seeds and use of insecticides in order to control pest attacks. However, farmers were left with no option when confronted with low productivity, lack of financial resource in the Departments of Collines and Plateau for instance (Table 6).

Farmers' preferences and traits sought in new varieties

The cluster analysis revealed four villages groups (Fig. 4). Villages in the same growing area were grouped together (Fig. 4). The cluster 1 grouped all the surveyed villages in the Departments of Zou and Collines. In these villages, early maturity and high yield were the major characteristics sought in pigeonpea varieties. Group 2 was

Table 6 Constraints encountered by pigeonpea farmers and coping strategies

Departments/municipalities	Constraints (ranked from main important to less important)	Coping strategies developed by
Collines (Savalou, Glazoué and Ouèssè)	Difficulty to harvest	Hired labor and mutual aid
	Production negatively affected by high rainfall	Left with no option
	Lack of financial resource	Left with no option
Zou (Zagnanado and Djidja)	Difficulty to harvest	Hired Labor
	Difficulty for threshing	Hired Labor
	Lack of financial resource to implement agricultural operations	"*Atcholou*" mutual aid to carry out cultivation operations
	Insects attack	Left with no option
Plateau (Pobè an Ketou)	Low yield	Left with no option
	Lack of financial resource to carry out at appropriate time production activities	Left with no option
	Non-availability of quality seed	Reuse of saved seed
	Difficulty to have access to market	Left with no option
Couffo	Lack of quality seed (low rate of germination)	Reuse of saved seed
	Low yield	Purchase cultivars of CARDER variety (a variety introduced by extension service)
	Insect attack on flowers and seeds	Use of insecticides

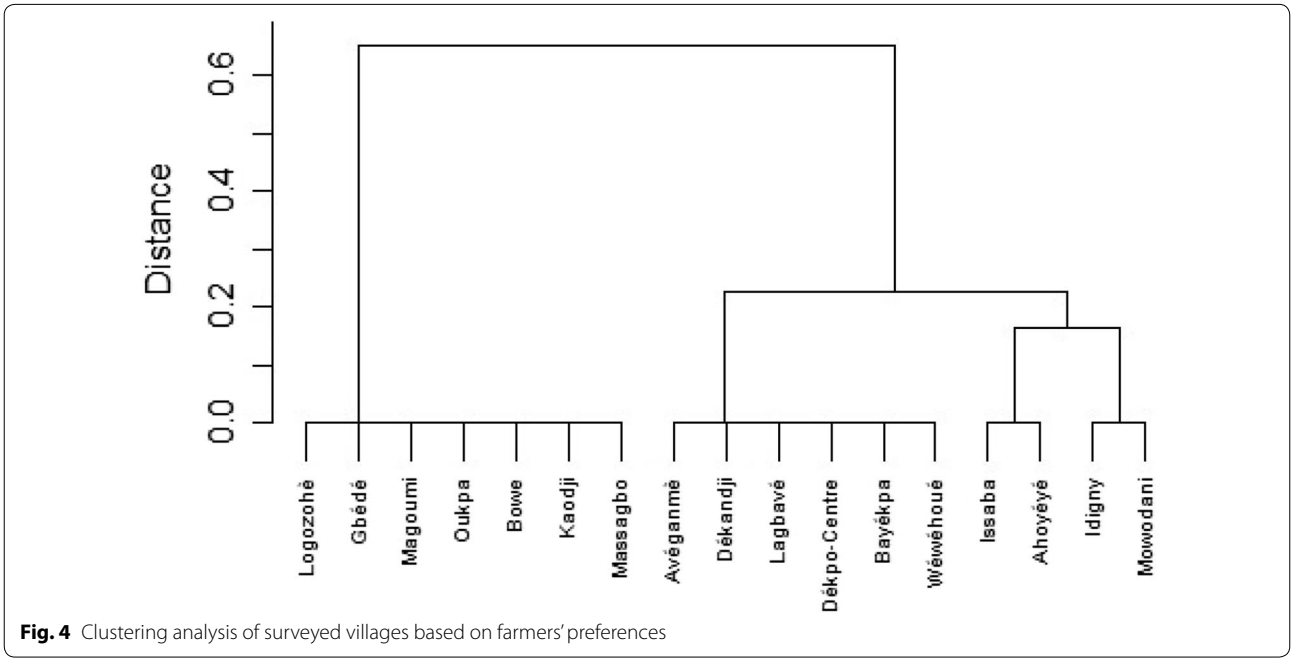

Fig. 4 Clustering analysis of surveyed villages based on farmers' preferences

composed of surveyed villages Ahoyéyé and Issaba, in the municipality of Pobè (Department of Plateau). In these villages, apart from high yield and early maturity, farmer enumerated resistance to pod borers, tolerance to flood and grains attributes such as sweet grains taste and short cooking time as desired traits in new varieties. Villages in the Group 3 are located in the Department of Couffo, and farmers in this area shared the desired traits listed in the municipality of Pobè except tolerance to flood. In addition, big seed size was part of the desired traits in Couffo. Cluster 4 grouped surveyed villages, Mowodani and Idigny, located in the Municipality of Ketou. Farmers' preferences were related to high yielding, early maturity, resistance to pod borers, sweet taste of grains and short cooking grains. Two criteria, namely high yielding and early maturity, were commonly mentioned by farmers across the growing areas, while traits like tolerance to flood or big seed size were specific to farmers

in the municipality of Pobè and Department of Couffo, respectively.

Discussion

Pigeonpea production practices and gender role

Pigeonpea is an important crop integrated in cropping systems in growing areas in Benin. The crop is mainly grown by adult and experienced men. This observation suggests that farmers have accumulated knowledge related to the crop through years of cultivation and exchanges with elders and other farmers [30]. The socioeconomic data about the pigeonpea growers are of great importance to identify those to be included in a participatory varietal selection or participatory plant breeding programs. It is worth noting that pigeonpea production in Benin is confined to the southern and central regions, while its cultivation could be more adapted to the northern regions of the country with less rainfall. This observation may be an opportunity to expand the cultivation to these areas, which are more prone to drought. However, sociocultural factors that may limit the cultivation of the crop in these regions of Benin need to be investigated for successful introduction of the crop.

Pigeonpea was grown in association with various crops species due to its slow growth during the 2–3 months after sowing [31]. Thus, depending on the growing area, pigeonpea was mainly associated with maize, cassava, cowpea, groundnut and vegetables. The Department of Couffo recorded the highest crops combination with pigeonpea. This Department is characterized by degraded soil and a high pressure on agricultural land [32], and pigeonpea has been promoted to cope with depletion in soil fertility [13, 14]. As a result, pigeonpea is associated with a wide range of crops in the production systems in this area. The association of pigeonpea with maize and cassava was reported in other pigeonpea-growing countries for instance in Nigeria [5], Uganda [16] and Kenya [18]. Few pigeonpea growers planted the crop in pure stand. Similar result was observed in Tanzania, Uganda and Kenya [16, 19, 33]. The primary reason given by farmers was that pigeonpea has a long growth cycle and its cultivation in sole crop occupies land that should be used for other crops. As such, farmers may be more willing to grow in pure stand early or extra-early pigeonpea cultivars since they can harvest within a short period (3–4 months) and allocated the land for other crops. In crop rotation system, pigeonpea was reported to control weeds and improve soil fertility for subsequent crops notably maize. This observation was consistent with findings of similar studies [4, 10]. In fact, as a legume, pigeonpea fixes atmospheric nitrogen in its various parts and the leaves drop forming litter and root residues enhance soil fertility [8, 34].

Most of the farmers used no product to conserve pigeonpea grains. Nevertheless, some farmers use chemical products and indigenous products to conserve their grains. The chemicals products used by farmers to conserve pigeonpea grains are not registered for such use. Consumption of pigeonpea grains treated with these products with residual and toxic ingredients might be detrimental to consumers' health [35].

The majority of pigeonpea growers saved seed for planting next season. Similar observation was made for many other crops in developing countries where most of the farmers saved seed for the next planting season and few of the farmers purchased seeds [16, 19, 36]. To some extent, this situation is the result of a non-existing formal seed system [10, 37, 38]. The informal seed system involving seed exchanges among farmers and among villages as well favors the introduction of new varieties or helps to spread existing cultivars across villages [39, 40]. However, farmer-saved seed and seed acquisition from market do not guarantee physical and genetic purity and an acceptable germination percentage [21, 40]. Currently, apart from sporadic seeds distribution to farmers by extension services, there is no formal seed supply system for pigeonpea in Benin. It is important to make available to farmers good quality seed in order to increase productivity of pigeonpea [21]. Hence, farmers should be trained in seed production of crops that are not covered by private seed companies.

Both male and female pigeonpea producers were differently involved in decision making regarding to farming activities and income management. To perform the labor-intensive operations such as land preparation (clearing, plowing), weeding, harvesting and threshing, households often hired labor or get involved in mutual aid groups. This observation was in agreement with finding on fonio (*Digitaria* spp.) in Togo [41]. The relatively low proportion of female involved in pigeonpea production as compared to other crops may be explained by its long life cycle, and then, its cultivation requires access to land on long duration. Such condition is difficult to fulfill by female who, in Benin, are rarely landowner [20]. Popularization of early or extra-early-maturing cultivars may make the cultivation of pigeonpea more attractive to women. Contrary to our observation, that is, women were more involved in pigeonpea commercialization, in some regions in Tanzania (e.g., Babati), men played the major role in pigeonpea grains commercialization probably because in this region, pigeonpea was introduced as cash crop [8]. This suggests that the role played by male and female in pigeonpea value chain is context specific and depends on the status, subsistence or commercial, of the crop.

Several constraints hampered farmers in their production activities to which they respond by adopting mitigating measures. Lack of improved varieties to meet farmers' needs is one of the major constraints limiting pigeonpea production. Furthermore, in regions where improved varieties exist, there is no functioning supply seed system since seed enterprises and governments are unwilling to invest in crops others than cash crops [37]. Poor agronomic practices, lack of improved varieties and quality seeds and lack of organization of the pigeonpea market negatively affect pigeonpea productivity and the capacity of farmers to sell their products at fair prices [4, 10, 37]. Farmers developed coping strategies including seed saving and/or exchange to have access to seeds. Furthermore, farmers resort to mutual aid to maintain their field and cope with lack of labor and lack of financial resources. Existence of improved varieties, farmers' organizations and market outlets both at national and at international levels [9] can be capitalized on to alleviate the constraints and develop pigeonpea value chains in Benin.

Farmers' preferred traits of desired varieties and implications for varietal development

Farmers' varietal preferences are based on their desire to meet socioeconomic and agroecological conditions [20, 22]. Failing to take into account these traits may hinder the success of any pigeonpea varietal improvement program targeting these areas. The preferred traits stated by farmers were early maturity, high yielding, big seed and flood tolerance, resistant to pod borers, short cooking time and grains taste. Farmers' preference for early-maturing cultivars is driven by the desire to get quick return on their investments, multiple harvests in one season, to limit competition of pigeonpea with intercropped species and to reduce the extent of yield loss because of drought at the end of the season [42, 43]. The preferred seed attributes such as big seed size, short cooking time and taste were probably based on consumers' preferences. In South Africa, Gwata and Silim [44] reported consumers' preference to white seed color in pigeonpea, which drive the choice of varieties by farmers. Even though within a given village, varieties preferences criteria may depend on gender, sociodemographic conditions, cropping systems [45], grouping of villages based on the preferences criteria may facilitate variety popularization and seed production. In fact, the outcrossing rate of pigeonpea is relatively high, up to 24% [46]. To cope with this challenge in seed production and maintenance of genetic purity of released varieties, the concept of "seed village," whereby all farmers in a village are encouraged to grow one variety of pigeonpea [21].

Up to now, none of the grown varieties is early maturing and there is no ongoing pigeonpea breeding program in the country. Thus, the only source of improved varieties is introduction from International research Institute notably International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Varieties to be introduced for evaluation should have the major traits identified in this study to increase their chance to be adopted by farmers. However, prior to varieties introduction, we recommend a collection, characterization and evaluation of Beninese pigeonpea germplasm.

Conclusion

This study sheds light on the production systems of pigeonpea. Farmers grow pigeonpea in association with a diversity of crops species. In so doing, they seek to rationalize land use and improve soil fertility. Several factors including non-availability of quality seed and poor agronomic constrain pigeonpea production. Support has to be provided to farmers in terms of access to quality seeds by training them in seed production. Pigeonpea growers seek traits such as early maturing, high yielding, insect resistance and large seeded varieties. Breeding or introducing varieties having those traits would increase the rate of adoption and subsequently the productivity of the crop assuming there is appropriate seed production and delivery system. In addition to improved varieties, researchers should develop technological packages for pigeonpea production and decisions makers should create conducive environment for farmers to have access to inputs (seeds, fertilizers and insecticides), credit and market.

Abbreviations

ICRISAT: International Crops Research Institute for the Semi-Arid Tropics; MAEP: Ministère de l'Agriculture, de l'Elevage et de la Pêche.

Authors' contributions

MATA designed the study, collected and analyzed data and drafted the manuscript. OK, AEL and DA supervised data analysis and revised the manuscript. All authors read and approved the final manuscript.

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MATA is a Research Assistant at the West Africa Centre for Crop Improvement, University of Ghana. This manuscript is part of his Master of Philosophy (MPhil) thesis on "Assessment of phenotypic diversity and farmers' knowledge of cultivation and utilization of pigeon pea [*Cajanus cajan* (L.) Millspaugh] in Benin". KO (Ph.D.) is a Professor in plant breeding at the Department of Crop Science, University of Ghana; Legon. LEA (Dr.) is an Associate Professor in Cropping Systems at University of Abomey-Calavi. AD (Ph.D.) is a lecturer in molecular genetics at University of Ghana, Department of Crop Science and at the West Africa Centre for Crop Improvement (WACCI).

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Competing interests
The authors declare that they have no competing interests.

Availability of supporting data
The datasets supporting the conclusions of this article are included within the article.

Consent to participate statement
Prior to data collection, participants gave oral consent to participate in the study.

Consent for publication
The respondents were informed that their opinions were to be published in a scientific paper and gave their approval.

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