Annales des sciences agronomiques, Volume spécial
Journée Mondiale des Sols 2018 (1) : 65-77, 2020 ISSN 1659 - 5009

COWPEA [*VIGNA UNGUICULATA* (L.) WALP.] CROPPING SYSTEMS MAPPING AND FARMERS' PERCEPTION ON SOIL FERTILITY IN BENIN

N. F. ANAGO., G. D. DAGBENONBAKIN **, E. C. AGBANGBA**, T. C. B. OUSSOU **, F. CHABI *, A. SAIDOU * & G. L. AMADJI **

** Laboratory of Soil Sciences, School of Crop Production, Faculty of Agricultural Sciences, University of Abomey-Calavi, 01 BP 526 RP Cotonou, Benin - E-mail : firmin.anago@gmail.com ; Tel : (+229) 97750183*

*** Laboratory of Soil Science, Water and Environment, Research agricultural Center of Agonkanmey, National Institute of Agronomic Research of Benin, 01 BP 988 RP, Cotonou, Benin*

**** Laboratory of Applied Biology Research and Study, Polytechnic School of Abomey-Calavi, Department of Environment genius, University of Abomey-Calavi, 01 BP 526 RP Cotonou, Benin*

ABSTRACT

Cowpea is an important legume crop in West Africa. However, in Benin, the cowpea grain yield is very low due to the soil depletion which induces food insecurity. To better understand the current management of soil fertility under cowpea production and farmers' perception on soil fertility, survey was conducted among 562 farmers in three geographical zones (southern, central and northern) of Benin. Results showed that main areas under cowpea production are in central (1.09 ± 0.85 ha) and southern (1.28 ± 1.16 ha) Benin. Three cowpea cropping systems were identified. There are farmers (13.18%) who grow cowpea in association with a cereal, use mineral fertilizers, practice manual tillage and bury crop residues in the soil. This practice is more observed in southern Benin where there was a low availability of arable land. The second cropping system involves farmers (56.22 %) who grow cowpea in a rotation system without intercropping and mineral fertilizer but practice manual tillage and bury crop residues on the soil. This system was more adopted in central Benin. The third crop system was observed in the northern part of the country where farmers (30.60 %) grow pure cowpea in a rotation system with a harnessed tillage and crop residues were used as animal feed. Farmers in all areas recognized that soil fertility was declining, based primarily on changes in yields. This decline in soil fertility is the main abiotic constraint that limits the production of cowpea. Then, determination of fertilizer rates which optimize cowpea yield is necessary to improve its productivity.

Keywords : *endogenous knowledge, declining of soil fertility, rotation system*

CARTOGRAPHIE DES SYSTÈMES DE CULTURE DE NIÉBÉ [*VIGNA UNGUICULATA* (L.) WALP.] ET PERCEPTION DES PRODUCTEURS SUR LA FERTILITÉ DES SOLS AU BÉNIN

RÉSUMÉ

Le niébé est une culture légumineuse plus cultivée en Afrique de l'ouest. Cependant au Bénin, le rendement grain de niébé est très faible en raison de la baisse de la fertilité des sols qui induit l'insécurité alimentaire. Pour mieux comprendre la gestion actuelle de fertilité des sols sous la culture du niébé et la perception des producteurs sur la fertilité des sols, une enquête a été effectuée auprès de 562 producteurs dans trois zones géographiques (sud, centre et nord) du Bénin. Il résulte de cette enquête que la production du niébé est plus importante au centre (1,09 ± 0,85 ha) et dans le sud (1,28 ± 1,16 ha) Bénin. Trois systèmes de culture du niébé sont identifiés. Il y a des producteurs (13,18 %) qui produisent le niébé en l'associant à une céréale, fertilisent les champs avec des engrais minéraux, pratiquent le labour manuel en billon et enfouissent les résidus de récoltes aux sols. Cette pratique est plus observée dans le sud Bénin où il y a une faible disponibilité de terre cultivable. Il y a ensuite des producteurs (56,22 %) qui cultivent le niébé dans un système de rotation sans l'association culturale ni l'application d'engrais minéral, pratique le labour manuel en billon et enfouissent les résidus de récolte aux sols. Ce système est plus adopté au centre Bénin. Au nord il est rencontré majoritairement des producteurs (30,60 %) qui font la culture pure du niébé dans un système de rotation avec un labour attelé et les résidus de récoltes servant à l'alimentation des animaux. Les producteurs de toutes les zones reconnaissent que la fertilité des sols baisse en se basant principalement sur l'évolution des rendements. Cette baisse de la fertilité des sols constitue la principale contrainte abiotique qui limite la production du niébé. Ainsi il est nécessaire de déterminer des doses d'engrais qui optimisent le rendement du niébé, pour améliorer la productivité de cette culture au Bénin.

Mots clés : connaissances endogènes, baisse de fertilité du sol, système de rotation

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp.) is a legume crop widely grown in the tropics and subtropics areas (Adusei *et al.*, 2016). West and Central Africa produce more than 60 % of the global cowpea production (Singh *et al.*, 1997). Cowpea is drought tolerant, fixes nitrogen (N), and possesses adaptability to grow in different cropping systems (Coulibaly & Lowenberg-DeBoer, 2002). It constitutes an important source of nutrients and income to poor resources small-scale farmers in Africa. Cowpea is rich in proteins, vitamins, mineral and highly caloric elements (Onwubiko *et al.*, 2011, Adeyemi *et al.*, 2012 ; Kudre *et al.*, 2013). The crop plays an important role as a primary source of protein, especially in areas where consumption of animal proteins is precluded because of inaccessibility, poverty or dietary preferences (Muranaka *et al.*, 2015). Cowpea constitutes also a food of choice for livestock (Iqbal *et al.*, 2015).

Cowpea is a food and nutrition security crop in Benin (Boyé *et al.*, 2016 ; Gbaguidi *et al.*, 2015). Cowpea is one of the most widely grown and consumed legume crops in Benin (MAEP, 2012). It ranks second legume after peanut according to farmers (Gbaguidi *et al.*, 2015). This shows that over the last five years, there has been a decline in cowpea production in Benin in favor of peanut. Cowpea on-farm yield is very low and the national production falls short to meet the local demand for cowpea (Nouhoheflin *et al.*, 2003). This is attributable to a range of constraints including the declining in soil fertility (Bado, 2002). In fact, for the crop to express its full potential in improvement of soil fertility through nitrogen fixation and increase productivity, cowpea crop must not be affected by mineral deficiency in the soil (Amadji *et al.*, 2007). Phosphorus and potassium deficiency can affect nitrogen fixation by cowpea and its grain production (Bado, 2002 ; Houngnandan, 2000). Unfortunately, the traditional cropping systems, generally mining, contributes to depletion of soil mineral stock and low yield (Chianu *et al.*, 2012). Knowledge about standard fertilizers formulation used by farmers in cowpea production in Benin is scanty. Therefore, there is need to characterize the cowpea cropping systems in Benin to establish a background information for developing better alternative to limit mineral deficiency in cowpea production. This requires a deep understanding of the perceptions as well as the endogenous practices used by farmers to maintain the soil fertility under cowpea production in Benin.

The goal of this research was to identify the main cowpea cropping systems and to analyze farmers' perception about the level of fertility of the soil under cowpea in Benin.

MATERIAL AND METHOD

Study area

This study was conducted in Benin, West Africa located between latitudes 6°10N and 12°25N and longitudes 0°45E and 3°55E (Gbaguidi *et al.*, 2015). Benin is divided into 12 departments spread over three geographical zones, namely the south, the center and north. The south and the center are relatively wet with two rainy seasons for maize, peanut and cowpea crops (Nouhoheflin *et al.*, 2003) and average annual rainfall varying from 1100 to 1400 mm/year. The soils in south zone are highly leached Ferralitic soils. The high population pressure observed in this zone reduces fallow time and contributes more to soil degradation (Nouhoheflin *et al.*, 2003). In central Benin, tropical Ferruginous soils with no concretions or concretions with medium fertility and hydromorphic soils are often encountered (Capo-chichi, 2006 ; Kouelo *et al.*, 2012). The northern part of the country is arid or semi-arid characterized by a single rainy season (Nouhoheflin *et al.*, 2003) unpredictable and irregular rainfall amount ranging between 800 and 950 mm/year. In northern Benin, soils are generally Ferruginous tropical leached with concretions on sand-clay sediments. Cotton farming with livestock are highly developed and this gives the area a characteristic of a socio-economic dynamic zone. In this study Banikoara and Kandi districts represent North Benin; Ouèssè and Glazoué districts Center-Benin and Agbangnizou and Kétou districts south Benin. Those municipalities were chosen because of cowpea grow by farmers and they also belong to research and development sites of the three geographical zones of National Institute for Agriculture Research in Benin.

Sampling method and data collection

Structured interviews were carried out among farmers. The sample size was determined using the normal approximation to the binomial distribution proposed by Dagnelie (1998): $Ni = [(U_{1-\alpha/2})^2 \times pi\ (1-pi)]/d^2$; with $U_{1\alpha/2}$ the value of the normal random variable for a probability of 1-α/2, α being the risk of error. For α = 5 %, the probability 1-α/2 = 0.975 and we have $U_{1-\alpha/2}$ = 1. 96, pi is the proportion of farmers involved in cowpea production in the study site and d the estimation margin error which is 5 % for this study. If B*n* is the percentage of famers involved in cowpea production in a district*,* B*n* = Bc*n*/Bt*n* (Bc*n* number of farmer of a district engaged in the cultivation of cowpea and Bt*n* total number of farmer of all districts). Thus the sample size of each district would be : n = B*n**N*i*.

Farmers were identified in each village by a random simple sampling method. A total of 562 farmers were surveyed including 90 in Banikoara, 88 in Kandi, 98 in Ouèssè, 106 in Glazoué, 84 in Agbangnizoun and 96 in Kétou. Data collected include the socio-economic characteristics of the farmers (age, sex, production experience, area planted, contribution in the household income, the method of claiming land), the cultural practices of cowpea farmers about fertility management soil, yield evolution, the perception of farmers on soil quality and production constraints.

Data processing and analysis

Statistical analyses were carried out using R statistical software version 3.5.1. Quantitative data from the individual survey were subjected to analysis of variance (anova) using the function *lm* in R. The package *FactoMineR* (Husson *et al.*, 2014) with the function *MCA and HCPC* and package *Factoextra* (Alboukadel and Fabian, 2017) with the function *fviz_mca and fviz_cluster* were used to run multiple correspondence analysis followed by a hierarchical clustering of the survey data related to cropping systems. This allowed us to identify the dominant cropping systems and the distribution of farmers according to cropping systems. In order to analyze the possible links between cropping systems and agro-ecological zones, gender and educational level, Chi^2 tests were carried out with the function *Chisq.test*. The package MASS with the function *Polr* (Brian *et al.*, 2018) was used to perform ordinal polytomial logic regression to identify the determinants of farmers' perception on soil quality. The correspondence analysis (CA) were carried out with the function *CA* of the package *FactoMineR* (Husson *et al.*, 2014). These CA allowed to visualize the probable links between farming systems and agro-ecological zones, ethnic groups and the level of education of farmers.

RESULTS

Socio-economic characteristics of cowpea farmers

Eighty-five percent (85 %) of the farmers surveyed were men while 15 % were women. Of these, 46 % were illiterate and have never gone to school, 32 % have primary school level, and 22 % have attended at least one class of secondary school. The age of the farmers surveyed varied between 17 and 60 years. They came from households whose size varies between 2 and 12 peoples. The analysis of variance results (Table 1) indicates that the households size, the available land area, the area harvested and the cowpea planted area were significantly influenced ($p < 0.0001$) by the agro-ecological zone of the farmers. The average household size in central Benin was higher than that of the northern and southern Benin. Seventy- seven percent (77 %)

of households were monogamous. There was no a significant difference between central and southern Benin in terms of the cowpea planted area. For these two areas, the cowpea planted area was on average between 1.09 ± 0.08 ha and 1.28 ± 0.20 ha. However, the cowpea planted areas in the north were significantly different from those in the southern and central Benin. In northern Benin, farmers planted in average 0.56 ± 0.21 ha of cowpea. The areas generally exploited by farmers for all their productions were between 0.5 and 30 ha but the cowpea planted areas varied between 0.25 and 5 ha.

Fifty-eight percent (58 %) of farmers were solely engaged in agriculture (crop production and/or breeding) as their only source of income, and the remaining 42 % associated agriculture and other activities. Among the respondents, 75.8 %, 18.5 % and five point seven percent (5.7 %) produced cowpea for self-consumption and marketing, self-consumption and exclusively marketing respectively.

The mode of land acquisition was mainly by inheritance (71.5 %) followed by lease (14.6 %), purchase (10.7 %) and donation (3.2 %). Eighty-three percent (83 %) of farmers grew cowpea with their own money compared to 17 % who used loans from microfinance institutions and/or friends. Thirty-three percent (33 %) of farmers used only family labor for cowpea production. Fifty-seven percent (59 %) of the farmers associated the family labor and the occasional hired labor for at least one cultural operation while eight percent (8 %) of farmers use only hired labor for production.

Table 1. Socio-economic characteristics of cowpea producers according to agro-ecological zones

Areas	Ages (years)	Household size (person)	Available area for agriculture (ha)	Area exploited for agriculture (ha)	Area cowpea (ha)	Experience in cowpea production (years)	Duration of land use (years)
North Benin	38.24 ± 9.98a	6.55 ± 2.8a	7.15 ± 5.86a	6.85 ± 5.37a	0.56 ± 0.48a	10.23 ± 6.83a	12.03 ± 5.84a
Benin Center	38.49 ± 5.81a	7.32 ± 1.96b	8.88 ± 3.98b	6.8 ± 2.95a	1.09 ± 0.85b	11.79 ± 5.89a	11.48 ± 5.25a
South Benin	40.37 ± 7.9a	5.96 ± 1.87a	5.24 ± 4.8c	4.36 ± 3.09c	1.28 ± 1.16b	10.23 ± 5.98a	10.23 ± 5.96a
P-value	0.14	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.20	0.09

Means followed by the same alphabetical letters and for the same variables are not significantly different (p > 0.05) according to the Student Newman-Keuls test

Cowpea cropping systems

Cowpea sowing periods varied from one area to another. In northern Benin, cowpea was sown only once between July and August by most farmers. In southern and central Benin, cowpea was sown twice and sowing was done in early April during the long rainy season and mid-August to early September during the short rainy season. The majority of farmers collected seed from previous harvest (64 %). In contrast, thirty-six percent (36 %) of farmers bought seeds on the local market. Manual tillage was practiced by sixty-six percent (66 %) of farmers. It should be noted that this type of tillage was found in central and southern Benin. On the other hand, thirty percent (30 %) practiced tillage with animal traction. This last practice was more developed in the north and at some extent in center-Benin. Eighty percent (80 %) of farmers grew cowpea in pure culture compared to twenty percent (20 %) who grew cowpea commonly in association with corn. In addition, eighty percent (85 %) of farmers produced cowpea in a crop rotation system with maize, sorghum, and cotton.

The multiple correspondence analysis carried out on the characteristic of cropping systems (mineral fertilizer use, cultural association, crop rotation, seed supply, tillage method, use of crop residues) indicates that the first five (5) axes account for 60.82 % of the information related to these variables characteristic of cropping systems. Considering Axes 1 and 2 (Figure 1) and the results of the ascending hierarchical classification (Figure 2), three farmers groups were identified. The first farmer group used mineral fertilizers, grew cowpea as a crop associate to maize, practiced manual tillage and incorporated crop residues into the soil (System 1). The second farmer group didn't use mineral fertilizers, grew cowpea in pure culture, practiced manual tillage in ridge, incorporated or leaves crop residues on the soil and practiced crop rotation (system 2). The third farmer group didn't use mineral fertilizers, grew cowpea in pure culture, practiced harness tillage, used crop residues as animals feed, and practiced crop rotation (system 3).

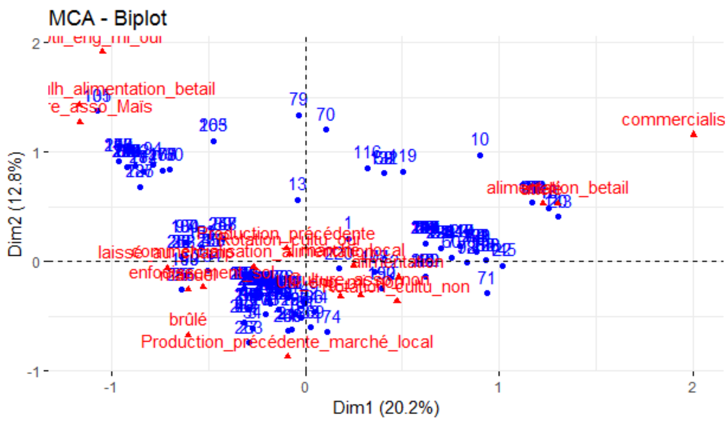

Figure 1. Representation of individuals and variables in the plan (Axis 1, Axis 2)

The system 2 was the most adopted by the farmers (56.22 %) followed by the system 3 (30.60 %). It worth noting that the main objective of the use of mineral fertilizer in system 1 was the fertilization of corn grown in association with cowpea.

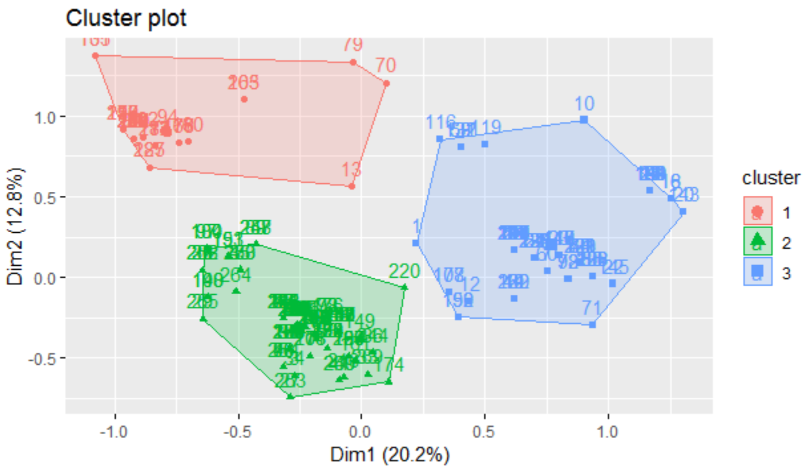

Figure 2. Grouping of producers in the plan (Axis 1, Axis 2)

Characterization of the cropping systems according to the socio-economic groups

The analysis of variances (Table 2) showed that there was a significant difference between cropping systems in regards to household size, the area available for farmers and cowpea planted area. No significant difference was observed between the cropping systems for the variables age and areas exploited. In fact, the farmers who adopted system 1 or system 3 came from lower household size and had lower land area as compared to system 2 farmers (Table 2). The farmers using system 1, system 2 had in average a large area for cowpea production estimated at 1.17 ± 0.86 ha and 1.18 ± 1.04 ha per farmer, respectively. In contrast to these, the farmers of System 3 had a small area for cowpea production (0.54 ± 0.98 ha).

The Chi² test showed that the choice of a cropping system by a farmer strongly depended on the agro-ecological zone (Chi² = 228 ; $p < 0.0001$), the sex (Chi² = 14.24 ; $p < 0.0001$) and the level of education (Chi² = 18.19 ; $p = 0.001$). Indeed, the results of the correspondence analysis (Figure 3a) showed that farmers in northern Benin adopted mainly the system 3, those in center Benin the system 2 while the southern Benin farmers adopted the system 1. Differences were also observed among the ethnic groups across the agro-ecological areas. Farmers using system 1 were mostly Adja, Fon and Yoruba (Figure 3b). Cropping system 2 farmers were of Manhi, Idatcha, Nago, Holli and Goun. Farmers using system 3 were of the Bariba, Djerman and Batonou ethnic groups. On the other hand, farmers of the system 1 had a secondary level of education, the farmers of the system 2 had a primary level of education while farmers of the system 3 were mainly illiterate.

Table 2. Socio-economic characteristics of cowpea producers according to cropping systems

Systems	Ages	Household size	Available area	Area exploited	Area cowpea	Experience in production	Duration of land use
System_1	39.43 ± 7.64a	5.62 ± 1.36b	5.80 ± 4.15b	5.07 ± 3.22a	1.17 ± 0.86a	10.75 ± 0.86a	10.86 ± 4.58a
System_2	39.57 ± 7.09a	6.96 ± 2.16a	7.92 ± 5.15a	6.26 ± 3.81a	1.18 ± 1.04a	11.52 ± 6.36a	11.35 ± 6.00a
System_3	37.80 ± 9.66a	6.48 ± 2.75a	6.35 ± 5.20ab	6.04 ± 4.79a	0.54 ± 5.56b	10.00 ± 5.98a	11.24 ± 5.62a
P-value	0.24	0.004	0.016	0.28	0.000	0.18	0.89

Means followed by the same alphabetical letters and for the same variables are not significantly different ($p > 0.05$) according to the Student Newman-Keuls test

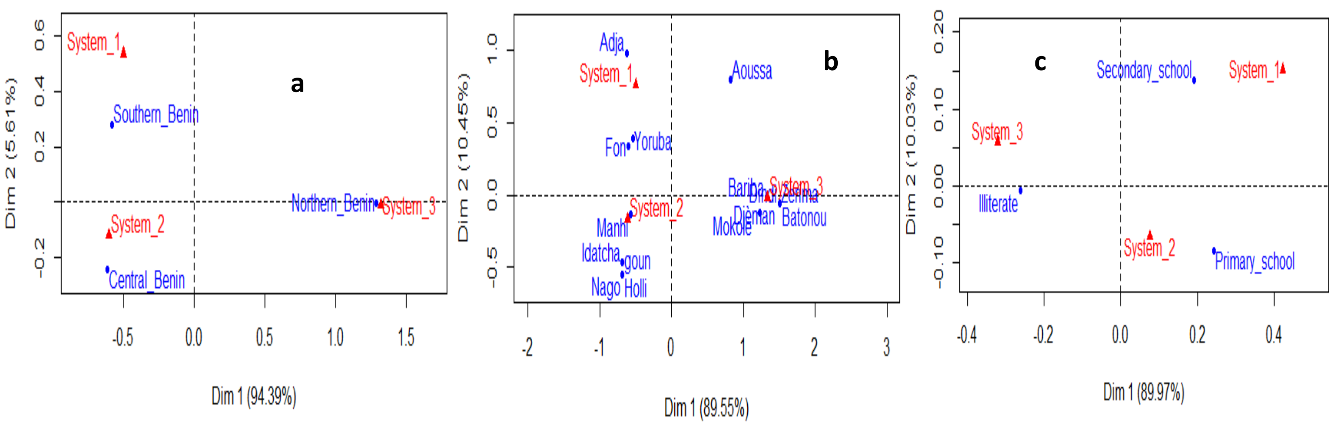

Figure 3. Representation of systems and agro-ecology zone (a), ethnic groups (b), level of education (c) in the plan (Axis 1, Axis 2)

Perception of producers on soil fertility

The surveyed farmers differentiated four levels of fertility of the soils they exploited: level 0 (mediocre fertility), level 1 (low fertility), level 2 (medium fertility) and level 3 (good fertility). The results of ordinal polytomic logistic regression (Table 3) showed that the cowpea planted area and the evolution of yields over the years had a significant impact on the perception of farmers on the soils quality (| t |>2). In fact, farmers considered that the exploited soils were fertile when they planted a large area for cowpea and/or when they had an increase in yields. The correspondence analysis (Figure 4a) showed that most farmers in northern Benin considered that the soils had a low level of fertility. Those in central Benin thought that the soils had good fertility. On the other hand, the farmers of southern Benin considered that the soils had medium fertility or mediocre fertility. In addition, Figure 4b showed that the Fon Idatcha, Adja and Yoruba ethnic estimated that the soils had mediocre or medium fertility while those from the Bariba, Batonou, Dindi and Goun ethnic groups believed that the soils had low fertility. Farmers of the Manhi, Mokolé and Aoussa ethnic groups considered that soils had good fertility.

Table 3. Result of ordinal logistic regression

variables	Coef.	Std. error	t-Value
SexeM	0.15	0.34	0.45
system2	-0.41	0.40	-1.04
system3	0.40	0.69	0.59
Education_Primary school	0.15	0.30	0.51
Education _Secondary school	-0.51	0.33	1.52
Household size	0.03	0.06	0.57
Cowpea planted Area	0.37	0.13	2.85*
Production experience	-0.08	0.05	-1.70
Duration of land use	0.09	0.06	1.58
Yield evolution	0.46	0.15	3.05*
Manual tillage	0.56	0.64	0.88
Tractor tillage	0.53	2.03	0.26

*Significant at the 0.05 level

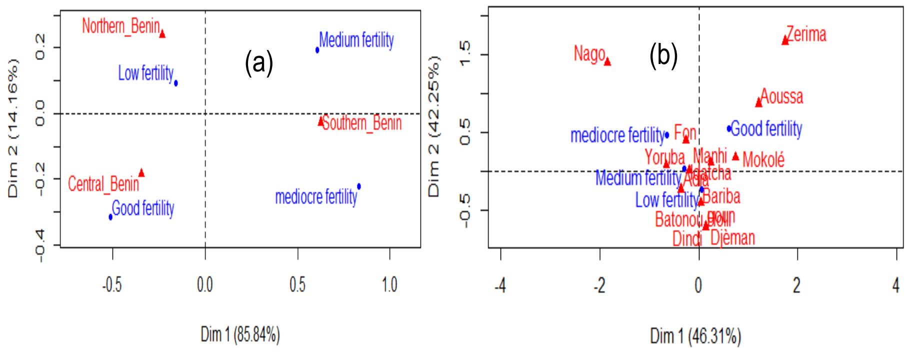

Figure 4. Representation of perception and les agro-ecology zone (a), ethnic groups (b) in the plan (Axis 1, Axis 2)

Cowpea production constraints

Figure 5 showed that by agro-ecological zone, the major constraints that limit cowpea production as perceived by farmers. The soil fertility declining followed by insect attack and drought were the most cited constraints limiting cowpea production in northern Benin (Figure 5a). Decline or loss of soil fertility followed by drought and attack of insects were the major constraints enumerated by farmers in central Benin (Figure 5b). On the other hand in southern Benin, it was rather the attack of insects followed by drought, decline of the fertility and heavy rains (Figure 5c) which constituted the major constraints limiting cowpea production.

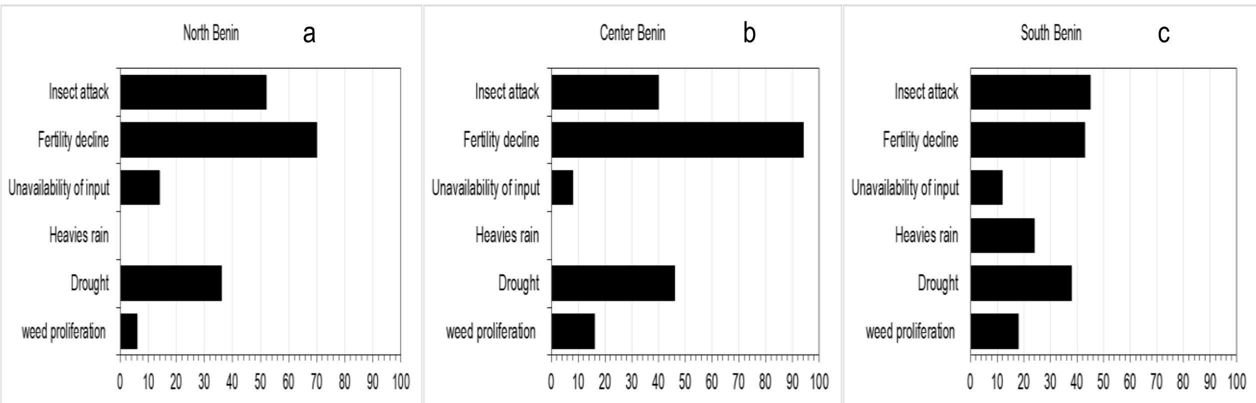

Figure 5. Major constraints limiting cowpea production in the north (a), center (b) and south Benin (c)

DISCUSSION

The cowpea farmers' age ranges from 17 to 60 years. Gbaguidi *et al.* (2015) had also reported that cowpea is grown by both young and old farmers in Benin. These farmers come from households of size ranging from 2 to 12 people. Cowpea production is higher in central and southern Benin with average cowpea planted areas greater than 1 ha. Cowpea are sown twice a year in central and southern Benin but only once in northern Benin. It is worth nothing that the cowpea seed sector is not organized. This situation leads the farmers in a large majority to get seeds through the previous harvest or to pay seeds on the market for sowing the next generation of the crop. Indeed, one of the major constraints of high productivity in West Africa is the lack of formal seed systems (Dossouhoui *et al.*, 2017). This limits the adoption of new improved cowpea varieties resulting in the low on-farm cowpea yield in Africa (Langyintuo *et al.*, 2008).

Most farmers in northern and central Benin grow cowpea in pure culture but in a cowpea-maize, sorghum or cotton rotation system. On the other hand, in southern Benin, cowpea is grown in association with maize. This option (system 1) in southern Benin is certainly due to the low availability of arable land to farmers as compared to central and northern Benin. The increasing economic importance of cowpea in recent years may explain this trend of monoculture of cowpea in this area (Coulibaly and Lowenberg-DeBoer, 2002). Farmers are well aware of the role of legumes in soil fertilization by fixing symbiotic atmospheric nitrogen (Laurette *et al.*, 2015 ; Do Rego *et al.*, 2015). It is therefore this collective consciousness of the farmers that justifies the choice of intercropping or rotation cowpea-cereal.

Only the farmers who adopted the system 1 characterized by the production of cowpea as a crop generally associated with maize, used mineral fertilizers. This mineral fertilization is mainly used for the main crop (cereal). The other two cropping systems, which differ in the plowing method and the use of crop residues, don't use mineral fertilization, although one of the major constraints to increasing cowpea productivity is depletion of soil minerals in particular phosphorus (Sanginga *et al.*, 2000). Phosphorus deficiency is the most important determinant of low cowpea yields in most tropical soils because of its role in root development and growth of rhizobial bacteria (Adusei *et al.*, 2016). Bado (2002) showed that cowpea fixes about 50 to 115 kg of nitrogen per hectare in tropical Ferruginous soils in Burkina Faso, which represents 52 to 56 % of its nitrogen requirements when cowpea is fertilized with phosphorus. In addition, a previous cowpea is equivalent to an application of 25 kg of nitrogen per hectare of mineral fertilizer for the subsequent crop.

While system 1 and 2 buried the crop residues on the soil, system 3 uses these residues as animals feed. Lawal *et al.* (2017) reported that dead cowpea leaves are the most used crop residues in urban and peri-urban animal feed in Niger. This practice is adopted in northern Benin, which is an area where livestock farming is highly developed. This intense livestock activity therefore justifies the adoption of the system 3 by farmers in the north. However, atmospheric nitrogen fixed by legumes is recycled to the soils through their residues (Bado, 2002 ; Chalk, 1998 ; La Rue & Patterson, 1981). The use of crop residues for animal feed cancels thus the positive effect of cowpea production on the improvement of soil fertility.

Farmers perceive differently the level of fertility of the soils used for cowpea production which varies according to their districts of origin and ethnic groups. Farmers mainly rate the level of soil fertility based on the area they plant for cowpea and the yields previously obtained on the soils. In fact, the perception of farmers was mostly correlated with the both previous yield and areas under cowpea. The farmers who obtained high yield over the last years plant a large area of cowpea and think that they soils were fertile. Akpo *et al.* (2016) also found that yield of the previous crops is the main criterion used by farmers for the assessment of the level of soil fertility. Although the perception of farmers on the level of soil fertility had deferred, they all recognize that this fertility decreases and constitutes an important constraint of production. Indeed, in the northern and central Benin, farmers perceive the loss of soil fertility as the first constraint limiting cowpea production. In south Benin this constraint ranks third after the attack of insects and drought. Loko *et al.* (2013) reported that the main abiotic constraints that limit cowpea production are loss of soil fertility, irregular rainfall and drought. In addition, Gbaguidi *et al.* (2015) in their study on farmers' perception on climate change determined that poor soil fertility is the primary abiotic constraint after the attack of insects in the field and storage which are biotic constraints.

CONCLUSION

This research showed that cowpea is grown across Benin. However its production is more important in central and southern Benin. Cowpea is grown by both young and old. Three cropping systems emerge from soil fertility management practices. These include cowpea production as a crop associated with maize, manual tillage, mineral fertilizer use and burying crop residues (system1); the production of cowpea in pure culture, manual tillage without the use of mineral fertilizers but crop residues is buried in the soil (system 2); and cowpea production in pure culture, tillage harness without the use of mineral fertilizers and crop residues are used for animal feed (system3). Systems 1, 2 and 3 are the most widely adopted in southern, central and northern Benin respectively. Farmers in southern Benin perceive that the soils have mediocre or medium fertility levels. Those in central Benin think that the soils have a good level of fertility. On the other hand, those in northern Benin reported that the soils have a low level of fertility. However, all farmers are aware of the decline in soil fertility and consider this as the main abiotic constraint that limits cowpea production in Benin. To increase the productivity of cowpea in Benin, it is therefore important to establish the standards rates of fertilizers application for optimum growth and productivity.

ACKNOWLEDGEMENTS

The authors are grateful to the Islamic Development Bank (IsDB) through Smallholder Agricultural Production Enhancement Program (SAPEP) for financial support and giving the opportunity to carry out this study.

REFERENCES

ADEYEMI S. A., LEWU F.B., ADEBOLA P.O., BRADLEY G. & OKOH A. I. 2012. Protein content variation in cowpea genotypes (Vigna unguiculata L. Walp.) grown in the Eastern Cape province of South Africa as affected by mineralized goat manure. African Journal of Agricultural Research, **7**(35), 4943-4947. DOI: 10.5897/AJAR11.1680

ADUSEI G., GAISER T., BOUKAR O. & FATOKUN C. 2016. Growth and yield responses of cowpea genotypes to soluble and rock P fertilizers on acid, highly weathered soil from humid tropical West Africa. Int. J. Biol. Chem. Sci. 10(4): 1493-1507, August 2016. Available online at http://www.ifgdg.org

AKPO M. A., SAÏDOU A., YABI I., BALOGOUN I., & BIO BIGOU L. B., 2016. Indicateurs paysans d'appréciation de la qualité des sols dans le bassin de l'Okpara au Bénin. Étude et Gestion des Sols, Volume 23, 2016 - 53 à 64

ALBOUKADEL K. & FABIAN M. 2017. Extract and Visualize the Results of Multivariate Data Analyses. URL: http://www.sthda.com/english/rpkgs/factoextra

AMADJI G. L., KONE B., AMOUZOUVI K. & AHOLOUKPE H. N.S., 2007. Amélioration de la production du niébé sur les terres de barre dégradées du Bénin. J. Rech. Sci. Univ. Lomé (Togo), 2007, série A, 9(2): 109-120

BADO B. V. 2002. Rôle des légumineuses sur la fertilité des sols ferrugineux tropicaux des zones guinéenne et soudanienne du Burkina Faso. Thèse de doctorat. Département des sols et de génie agroalimentaire, faculté des sciences de l'agriculture et de l'alimentation université LAVAL (QUÉBEC). Décembre 2002.

BOYE M. A. D., YAPO S. E. S., KOFFI N. B. C., KOUASSI N. J., TONESSIA D. C., SOKO D. F., BALLO E. K., SEU J. G., AYOLIE K. & KOUADIO Y. J. 2016. Etude de la qualité agronomique et biochimique de quelques variétés de niébé (Vigna Unguiculata (L) Walp (Fabaceae) provenant de la Côte d'Ivoire. European Scientific Journal August 2016 edition vol.12, No.24 ISSN: 1857 – 7881 (Print) e–ISSN 1857- 7431. URL:http://dx.doi.org/10.19044/esj.2016.v12n24p362

BRIAN R., BILL V., DOUGLAS M. B., KURT H., ALBRECHT G. and DAVID F. 2018. Support Functions and Datasets for Venables and Ripley's MASS. URL: http://www.stats.ox.ac.uk/pub/MASS4/

CAPO-CHICHI, J.G., 2006. La dégradation des terres et leur réhabilitation dans les zones arides du Bénin, In "Actes du séminaire international sur : Les ressources en eau douce et réhabilitation des terres dégradées dans les zones arides", N'djaména, Tchad, Octobre 2000, 65-70

CHALCK, P. M.1998. Dynamics of biologically fixed N in legume-cereal rotations: a review. Aust. J. Res., 49: 303-316.

CHIANU J., CHIANU J. & MAIRURA., 2012. Mineral fertilizers in the farming systems of sub-Saharan Africa. A review. Agronomy for Sustainable Development, Springer Verlag/EDP Sciences/INRA, 2012, 32 (2), pp.545-566. ff10.1007/s13593-011-0050-0ff. ffhal-00930525ff.

COULIBALY O. & LOWENBERG-DEBOER J. The economics of cowpea in West Africa. In FATOKUN C. A. et al. (eds) Proceedings of the Third World Cowpea Conference on challenges and opportunities for enhancing sustainable cowpea production, IITA, Nigeria, 2002; pp 351-366.

DO REGO A. F., DIOP I., SADIO O., DA SYLVA M. C., AGBANGBA C. E., TOURÉ O., KANE I., NDOYE A. M. N. & WADE T. K. 2015. Response of Cowpea to Symbiotic Microorganisms Inoculation (Arbuscular Mycorrhizal Fungi and Rhizobium) in Cultivated Soils in Senegal. Universal Journal of Plant Science 3(2) : 32-42. DOI : 10.13189/ujps.2015.030204

DOSSOUHOUI F. V., AGOSSOU S. M. D., ADEGBIDI A., MENDEZ DEL VILLAR P., TOSSOU C. R., & LEBAILLY P. 2017. Analyse de la rentabilité financière de la production de semence du riz au Bénin. J. Appl. Biosci. 2017

GBAGUIDI A. A., FAOUZIATH S., OROBIYI A., DANSI M., AKOUEGNINOU B. A. & DANSI A. 2015. Connaissances endogènes et perceptions paysannes de l'impact des changements climatiques sur la production et la diversité du niébé (Vigna unguiculata (L.) Walp.) et du voandzou (Vigna subterranea (L) Verdc.) au Bénin. Int. J. Biol. Chem. Sci. 9(5): 2520-2541, October 2015. Available online at http://www.ifg-dg.org

HOUNGNANDAN P., 2000. Efficiency of the use of organic and inorganic nutrients in maize-based cropping systems in Benin. Doctoral Thesis, University of Gent, the Netherlands, 196 pp.

HUSSON F., JOSSE J., LE S. & MAZET J. 2014 Multivariate Exploratory Data Analysis and Data Mining with R. URL: http://factominer.free.fr

IQBAL M. A. 2015. Evaluation of Forage Cowpea and Hey as a Feed Resource for Ruminant Production: A Mini Review Global Veterinaria, **14**(5): 747- 751 DOI: 10.5829/idosi.gv. 2015.14.05.937.

KOUELO A. F., BADOU A., HOUNGNANDAN P., FRANCISCO M. M. F., GNIMASSOUN C. J-B. & SOCHIME D. J., 2012. Impact du travail du sol et de la fertilisation minérale sur la productivité de Macrotyloma geocarpum (Harms) Maréchal & Baudet au centre du Bénin. Journal of Applied Biosciences 51: 3625– 3632

KUDRE T.G., BENJAKUL S. & KISHIMURA H. 2013. Comparative study on chemical compositions and properties of protein isolates from mung bean, black bean and bambara groundnut. Journal of the Science of Food and Agriculture, **93**(10): 2429-2436. DOI: 10.1002/jsfa.6052

LANGYINTUO A. S, MWANGI W., DIALLO A. O, MACROBERT J., DIXON J. & BÄNZIGER M., 2008. An analysis of the bottlenecks affecting the production and deployment of maize seed in eastern and southern Africa. Harare, Zimbabwe, CIMMYT.

LARUE, T.A. & PATTERSON T.G., 1981. How much nitrogen do legume fix? Advan. In Agron. 34: 15-38.

LAURETTE N. N., MAXEMILIENNE N. B., HENRI F., SOULEYMANOU A., KAMDEM K., ALBERT N., NWAGA DIEUDONNE & FRANÇOIS-XAVIER E. 2015. Isolation and Screening of Indigenous Bambara Groundnut (Vigna Subterranea) Nodulating Bacteria for their Tolerance to Some Environmental Stresses. American Journal of Microbiological Research, 3(2), 65-75. DOI: 10.12691/ajmr-3-2-5

LAWAL. M. A. A., CHAIBOU M., GARBA M. M., MANI M. & GOURO A. S. 2017. Gestion et utilisation des résidus de cultures pour l'alimentation animale en milieu urbain et périurbain : cas de la communauté urbaine de Niamey. Journal of Applied Biosciences 115: 11423-1143. Published online at www.m.elewa.org on 31st July 2017 https://dx.doi.org/10.4314/jab/v115i1.2.

LOKO Y. L., DANSI A., AGRE A. P., AKPA N., DOSSOU AMINON1 I., ASSOGBA P., DANSI M., AKPAGANA K. & SANNI A. 2013. Perceptions paysannes et impacts des changements climatiques sur la production et la diversité variétale de l'igname dans la zone aride du Nord-Ouest du Bénin. International Journal of Biological and Chemical Sciences, **7**(2) : 672-695.DOI : http://dx.doi.org/10.4314/ijbcs.v7i2.23

MAEP (Ministère de l'Agriculture de l'Elevage et de la Pêche). 2012. Données statistiques des spéculations au Bénin.

MURANAKA S., SHONO M., MANJULA K., TAKAGI H. & ISHIKAWA H., 2015. Application of near to mid-infrared spectroscopy to estimation of grain nitrogen content in cowpea (Vigna unguiculata) grown under multiple environmental conditions. Journal of Biological and Food Science Research ©2015 Online Research Journals. Available Online at http://www.onlineresearchjournals.org/JBFSR

NOUHOHEFLIN T., COULIBALY O. & ADEGBIDI A. 2003. Impact de l'adoption des nouvelles technologies sur l'efficacité de la production du niébé au Bénin. Bulletin de la Recherche Agronomique du Bénin N°40–Juin 2003.

ONWUBIKO N. I. C, ODUM O. B., UTAZI C. O. & POLYMBAH P.C. 2011. Studies on the Adaptation of Bambara Groundnut [Vigna subterranea (L.) Verdc.] in Owerri Southeastern Nigeria. New York Science Journal, **4**: 60-67. DOI: 10.3923/aj.2011.60.65.

SANGINGA N, LYASSE O & SINGH B. B. 2000. Phosphorus use efficiency and nitrogen balance of cowpea breeding lines in a low P soil of the derived savanna zone in West Africa. Plant Soil, 220: 119–128. DOI: http://dx.doi.org/10.1023/a:1004785720047

SINGH B. B. & EMECHEBE M. A. 1997. Advances in research on cowpea Striga and Alectra: 215-224. In: Singh, B.B., Mohan Raj, D.R., Dashiell, K.E., Jackai, L.E.N. (eds), Advances in Cowpea Research. IITA, Ibadan, Nigeria and JIRCAS, Ibaraki, Japan.