CHARACTERIZATION OF THE PEANUT PRODUCTION SYSTEMS IN THEIR MAIN AGRO-ECOLOGICAL REGIONS IN BENIN

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Abstract

The aim of the present study was to characterize the peanut production systems in two agro-ecological zones (AEZ) in order to pave the ways for the improvement of existing Agriculture-Farming Integrated Productivity Systems of Benin. Thus, 203 peanut producers were investigated in four rural communes in the AEZ III and AEZ V of Benin. The data collected relate to socioeconomic characteristics of producers, farming management practices, utilization of the peanuts' fans, market prices of peanut, input quantities and market prices, revenues for the crop production year 2013-2014, constraints on peanut production and farming methods. The results indicate that male producers are mostly producing peanut (69.7 %). The producers of the Center of Benin are significantly more experienced (17.76±0.72) than those of the North (14.33±0.77). Our observations show that two varieties are grown of which one is improved (Carder: 2087.68 ± 154.06 kg/ha) and another is local (Moto: 1309.38 ± 119.25 kg/ha). No significant difference ($P > 0.05$) exists between the two areas of production

in relation to the yields recorded for the peanuts production in the year 2013-2014. The major production constraints listed by the majority of producers (85 %) are the poor quality of seed, the lack of specific inputs and labor, the climatic hazards, mainly the pockets of drought, the poor distribution of rainfall and the excessive temperatures. In the two surveyed production areas, the majority of peanut producers (60 %) do not feed animals neither with dead leaves nor with food supplementation or fodder.

Keywords: Production systems, peanut, socio-economic characteristics, Benin

Resume

La présente étude a pour but de caractériser les systèmes de production de l'arachide dans deux zones agroécologiques en vue de l'amélioration des systèmes intégrés agriculture-élevage existants du Bénin. Ainsi, 203 producteurs d'arachide ont été enquêtés dans quatre communes rurales réparties dans les ZAE III et ZAE V du Bénin. Les données collectées sont relatives aux caractéristiques socio-économiques des producteurs, aux pratiques culturales en matière de gestion, aux destinations des fanes d'arachide, aux prix de vente de l'arachide, aux quantités et coûts des intrants, aux revenus de la campagne agricole 2013 – 2014, aux contraintes de production de l'arachide et aux modes d'élevage. Les résultats indiquent que les hommes sont majoritairement producteurs d'arachide (69.7 %). Les producteurs du Centre du Bénin sont significativement plus expérimentés (17,76±0,72) que ceux du Nord (14,33±0,77). Nos observations montrent que deux variétés sont cultivées à savoir celle améliorée (Carder : 2087,68 ± 154,06 kg/ha) et celle locale (Moto : 1309,38 ± 119,25 kg/ha). Aucune différence significative (P > 0,05) n'existe entre les deux zones de production en ce qui concerne les rendements obtenus au cours de la campagne 2013-2014 pour la culture de l'arachide. Les principales contraintes de production énumérées par la majorité des producteurs (85 %) sont la mauvaise qualité des semences, le manque d'intrants spécifiques et de main d'œuvre, les aléas climatiques, surtout les poches de sécheresse, la mauvaise répartition des pluies et les températures excessives. Dans les deux zones de production étudiées, la majorité des producteurs d'arachide enquêtés (60 %) ne nourrissent pas les animaux avec les fanes ni en complémentation alimentaire ni en fourrage.

Mots-clés : Systèmes de production, Arachide, caractéristiques socio-économiques, Bénin

Introduction

Peanut (*Arachis hypogaea L*., Fabaceae) is a leguminous plant native to Latin America (Kouadio, 2007). It is cultivated throughout the tropical and inter-tropical area (Shiyam, 2010) and have high nutritional and economic importance (Noba *et al.,* 2014). It is the sixth culture among the most important oleaginous in the world (FAO, 2013) and the twelfth production of crop worldwide (Fonceca, 2010). Peanuts produced in the world are mainly transformed in to oil, flour and derivatives entering in the composition of food products including confectionery, peanut butter and paste etc. (Revoredo and Fletcher, 2002). The remaining part that is the final products varies according to the production regions (Fonseca, 2010). For example, in United States of America, the peanut production for food represents 77 % while in West Africa it represents 55.3 % (Revoredo and Fletcher, 2002). Peanut contains 48-50 % of fats, 26-28 % of protein and is also rich in fiber, minerals and vitamins (FAO, 2003). Peanut is grown in more than 100 countries covering more than 26.4 million hectares with an average productivity of 1.4 tons per hectare (FAO, 2003; Barraud *et al*., 2004; Ntare *et al.*, 2008). According to Ntare *et al.,* (2008), developing countries hold 97 % of cultivated areas and 94 % of the overall production of this crop. The first producers' countries are China and India with more than 60 % of the world global production (Noba *et al.,* 2014). The African continent, with its 10 million hectares of peanut cultivated areas and its 10 million tons, ranks second ahead of the American continent (FAOSTAT, 2008). Africa supplies about 25 % of the production mainly Nigeria, Senegal and Sudan (Kouadio, 2007). Africa, although second continent in terms of production of peanut, has the lowest yields per hectare (1 t/ha), compared to America (3 t/ha) and Asia (1.8 t/ha) (Garba *et al.*, 2015). Apart from the peanut, dry leaves are commonly used in livestock's feeding in most of the Sahel countries.

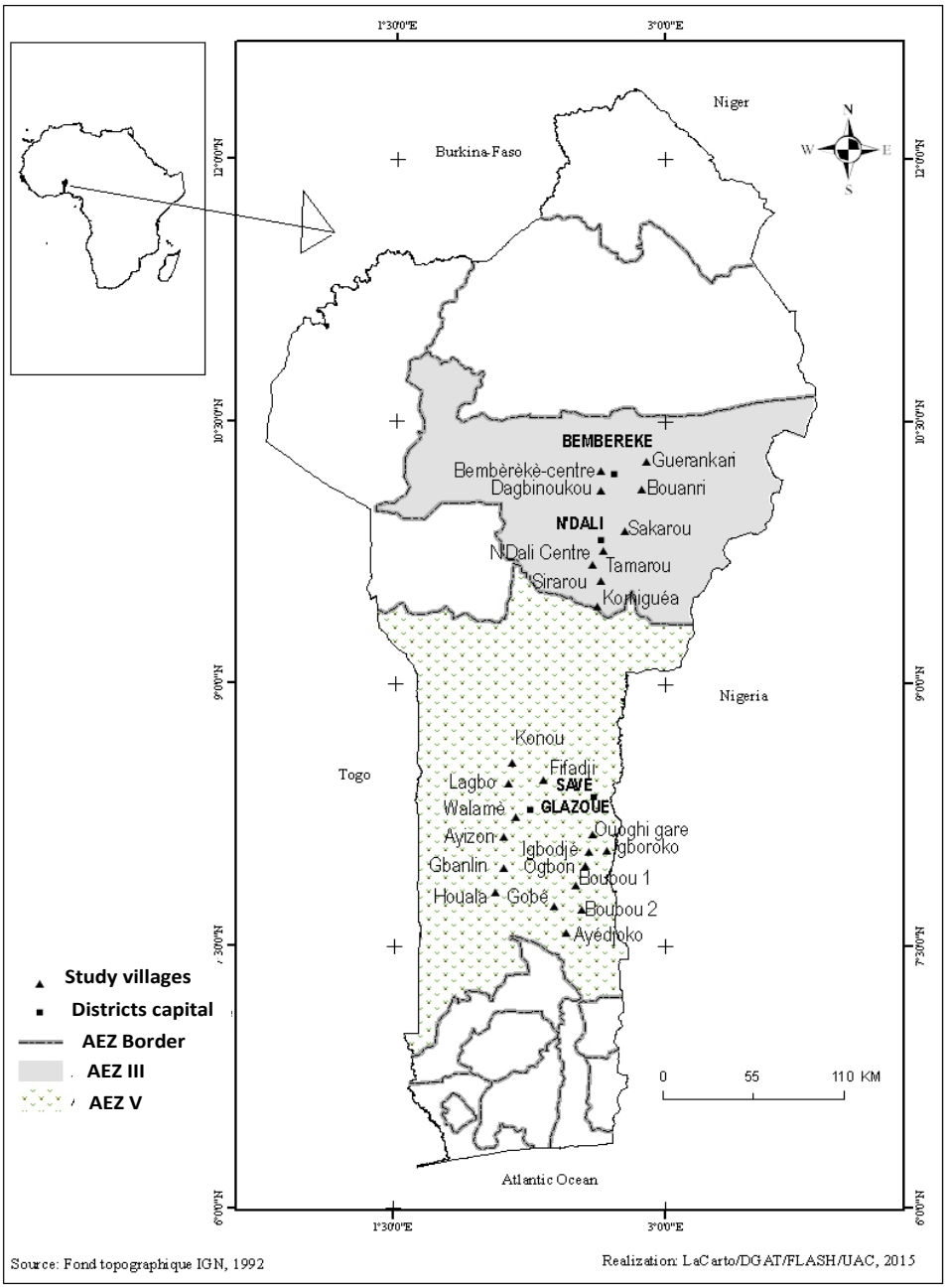
Considering the importance of this crop in Africa, it is necessary to solve the problem of low yields. One should notice that various constraints induce the decline of peanuts production (Montfort, 2005; Ndéné, 2011). These constraints are caused by the nature of agriculture policies, fluctuations in the market, low quality of agricultural equipment, climate changes etc. As a matter of fact, the entire sector is in a situation of doubt, and financial and organizational difficulties result in a gradual decrease of its contribution to GDP. Exports are estimated at about 6.5 % in Africa respectively in 2006 and 2001 (Noba *et al.* 2014). This decline of the peanut production in the national economy is felt by producers (Diop, 2013; Gaye, 2013). Beninese peanut producers are still facing recurrent and structural marketing problems. So, those constraints reduce the importance of the crop to the benefit of other sectors such as palm oil, soybean (Noba *et al.,* 2014) and cotton (Amouzou *et al.*, 2012).

Peanut production is very low in West African countries such as Benin. So, in spite of the increase in the peanuts cultivated areas from 2000 to 2012 (from 80,000 to 100,000 ha), yields remain very low (600 to 800 $kg.ha^{-1}$) (MAEP, 2012). According to Mboup (2004), peanut production since the end of 1970s goes through a structural crisis in West Africa and is not able to ensure regular supply to oil factories, maintenance of seed stocks and consumers' satisfaction. The increase in productivity and competitiveness improvement of the peanut sector will depend on three key factors: i) the reconstitution of the seed capital, ii) the improvement of the level of soil fertility (Anonyme, 2003; Diouf, 2013) and iii) genetic improvement by creating new varieties adapted to the conditions of different countries and of very short cycle (Faye, 2012). In Benin there is a lack of scientific information on the peanut production constraints. Thus, the present study purposely addresses the socio-economic profile of peanut-crop producers and the characterization of peanut production systems in two main agro-ecological regions of Benin.

Material and methods

Study area

The present study is conducted in four communes producing peanut in Benin namely the communes of Savè and Glazoué belonging on the agro-ecological Zone V (Center of Benin) and those of Bembereke and N'dali in agro-ecological zone III (North East of Benin) (Figure 1). The communes of Glazoué and Savè are located in the Collines Department. According to Balogoun *et al.,* (2014), this Department fully belongs to the zone of Guinea Sudano climate characterized by two rainy seasons covering the periods from April to July and from October to November. It is a transition zone (between South and North) of 16 900 km^2 that extends after Abomey and Kétou trays until the 9^{th} parallel north. This area is entirely occupied by tropical ferruginous soil leached or depleted soils (INRAB, 1995). As for the communes of Bembereke and N'dali, they are located in the Department of Borgou in the Sudanian zone, between the $9^{th}10^{th}$ parallel North (Balogoun *et al..*, 2014). It is characterized by a Sudanian climate with a rainy season from April to October and a dry season from November to March. The communes of Bembereke and N'dali are mainly dominated by tropical ferruginous soils with highly variable agronomic characteristics. According to INRAB (1995), soils are of fine clay-Sandy texture.



The districts names are in capital letters and those of villages in small letters.
Figure 1: Geographical location of the surveyed villages in two agro-ecological zones of Benin.

Choice of the study villages

Producers' cultural techniques (period of seedlings, maintenance of the peanut crop fields, application or not of fertilizers, mix-cropping, pest

management, use of the fallen peanut leaves etc.) are the main criteria of the selection of the study villages. Land availability, accessibility of the areas throughout the season and openness of producers to collaborate with the research team and the socio-cultural groups in presence are the additional criteria. On this basis, 24 villages are selected over 32 (table 2). Prior to the fieldwork, an exploratory study carried out from 1st to 10 October 2013, allows to have an overview on production techniques.

Table 2: List of surveyed villages per agro ecological zone regarding the socio-cultural groups.

AEZ	Region	Municipality	Village	Socio-cultural Groups
AEZIII	North East	BEMBEREKE	Guerankari	Bariba
			Bembereke-centre	Bariba
			Bouanri	Bariba
			Dagbinoukou	Bariba
		N'DALI	Sakarou	Bariba
			N'Dali Centre	Bariba et tchabè
			Tamarou	Bariba
			Komiguéa	Bariba
			Sirarou	Idaatcha et Bariba
AEZ V	Centre	GLAZOUE	Gbanlin	Mahi
			Fifadji	Mahi
			Ayizon	Mahi
			Lagbo	Mahi
			Konou	Mahi et Idaatcha
			Walamè	Mahi
			Houala	Idaatcha
		SAVE	Igboroko	Idaatcha
			Igbodjé	Fon et Ditamari
			Boubou 1	Fon, Tchabè et Ditamari
			Boubou 2	Tchabè et Fon
			Ogbon	Fon
			Ouoghi gare	Yom, Tchabè et Fon
			Gobe	Tchabè
			Ayedjoko	Tchabè et Fon

Sampling method

The size of the sample (N) is obtained using the normal approximation of the binomial distribution proposed by Moshood (1998):

$N= [(U_1-\alpha/_2)^2 \times p (1-p)] /d^2$**,** with

$U_1- \alpha /_2$(the value of the normal random variable for the value of probability of 1-A $/_2$), A (the risk of error). For $\alpha = 5$ % (1 % $\leq d \leq 15$ %), the probability $1 - \alpha /_2 = 0.975$ and there $U_1- \alpha /_2= 1.96$. P is the proportion of persons engaged in the production of peanut in the middle of study and d the margin of error in assessment, adopted at 5 % in this study.

Using the p values obtained from the exploratory phase, a total of 203

producers are randomly selected in the study at the rate of 100 producers in the center and 103 in the North.

Methods and data collection tools

Data from this study are collected in December 2014 using a semi-structured questionnaire which allows to collect quantitative and qualitative information. The types of data collected relate to socioeconomic characteristics of peanut producers, farming practices in the management of peanut crop, destinations of peanut fallen leaves, market prices of peanut, quantities and costs of inputs, revenues for the crop production year 2013-2014, the constraints on peanut production and the farming methods. Considered actual areas are those corrected by the difference between the declared values and those measured in GPS (mark Garmin eTrex 20) from a sample of approximately five peanut producers per village (Balogoun *et al.*, 2014). Yields are obtained from the sum of 100 kg bags per unit area and reported per hectare. In order to correct the gap between perceived and measured values, a measurement using an electronic scale is made on samples collected from five producers.

Processing and analysis of data

Data are first processed with a spreadsheet, MS Excel, and then analyzed with SPSS 16.0 in order to get descriptive statistics (percentages, averages, standard errors etc.). Variance analysis (ANOVA) is further performed using the procedure PROC GLM of SAS 9.2. Multiple mean comparisons are finally performed with the Student Newman-Keuls test (Dagnelie, 1986).

Results

Socio-economic characteristics of peanut producers

Table 3 presents the results of the descriptive analysis of socio-economic variables of peanut producers according to the two production areas in Benin. Generally, males producers grow much more peanut (69.7 %) than female (31.3 %). In any of the study areas, respondents are between 16 and 73 years old with an average of 38 years. The results display that most peanut producers (53.1 %) are between 30 and 50 years old, and they are also married (87.3 %). In the North, the majority of peanut producers are Muslims and native while they are Christians and allochthonous in the Center. However, a larger proportion of producers do not belong to any peasant organization (80.15 %) and are also not framed (83.5 %) by the competent structures. The majority of respondents (72.1 %) have more than 10 years of experience in the cultivation of peanuts.

Table 3: Socio-economic characteristics of peanut producers regarding the AEZ.

Variable	Modality	Percentage of Respondents (%)	
		North (n=103)	Center (n=100)
Sex	Male	55.4	84
	Female	46.6	16
Religion	Muslim	74.8	7
	Christians	25.2	64
	Animist	-	27
Age	< 30 years	34.3	17
	Between 30 and 50 years	53.1	56
	≥ 50 years	12.6	27
Situation Marriage	Married	80.6	94
	Single	15.5	6
Origin of head household	Native	65	47
	Allochthonous	35	53
Social Status	Peasants	58.3	78
	Tradespeople	30.1	7
Level of Education	No Schooling	40.8	52
	Primary	30.1	23
	Secondary 1st cycle	-	16
	Literate	10.7	4
Habit Type	Brick with cement roof sheet/tile	50.5	7
	Clay with Plate	45.6	68
	Clay with Straw roof	-	22
Source Lighting	Oil lamp	43.7	73
	Battery torch	35.9	5
	SBEE Electricity	5.35	11
Membership a Landscape Organization	Yes	8.7	31
	No	91.3	69
Bénéficed'encadrement	Oui	1.9	32
	Non	98.1	68
Experience in peanut cultivation	5-9ans	*28.2	12
	10-20ans	33	39
	≥ 20 ans	28.2	44
Area of Peanut	< 2 ha	83.5	59
	≥ 2 ha	16.5	41
Contribution to household income	Very important (> 60%)	38.8	3
	Important (40 – 60%)	43.7	70
	No Significant (< 40%)	17.5	27

Producers of the Center are more experienced in peanut production than those of the North ($P < 0.001$) (table 4). Independently to the areas, areas sown with peanuts per producers are less than 2 ha in spite of its important contribution to the household income (56.85 %). A areas sown with this crop, ages of producers, available areas and the number of children

are significantly higher in the Center than in the North (P < 0.001) (table 4). The majority of producers of the two production areas (70.3 %) consider the cultivation of peanut as income generating activities.

Table 4: Quantitative data (mean values ± standard errors) on Peanut production in the both production areas.

Zones	Age of peanut producers	Number of Children	Available Area (ha)	Area Harvested (ha)	Area Sown for peanut (ha)	Year of Experience in Producing Peanut
North	37.10±1,16**b**	4.12±0,31**b**	7.17±0,89**b**	5.55±0,57**a**	1.17±0,11**b**	14.33±0,77**b**
Center	41.87±1,19 **a**	5.76±0,40**a**	12.08±1,05**a**	6.99±0,56**a**	1.77±0,16**a**	17.76±0,72**a**
Probability	0.005	0.001	0.001	0.07	0.002	0.001

The means with the same alphabetic letters are not significantly different (P > 0.05) according to the Newman-Keuls test.

Factors of peanut production

Table 5 presents different factors of peanut production. The analysis of this table shows that land tenure systemis dominated by inheritance, sale and donation. Inheritance is a dominant acquisition mode (60.2 % in the north and 46 % in the center). Family labor is first relied on in the cultivation of peanut in the Center while salaried labor dominates in the northern zone. The use of the salaried labor varies from area to area. Casual workers (100 %) are the most requested in both production areas. The main activities carried out by family labor or employees are essentially land clearing, plowing, weeding and harvesting. Maintenance costs vary between 20.000 and 30.000 FCFA/ha in the Centre and between 25.000 and 40.000 FCFA/ha in the North. Remuneration for work force peanut crop production can be in cash payment or in kind. In the present case, for the cash payment, prices vary between 10,000 and 15,000 FCFA/ha. Concerning the compensation in kind (arrangement with Aboriginal most often), workers receive in return between 1/4 and 1/5 of the harvested peanuts or half of the fallen leaves depending of the contract.

The majority of producers of the two study areas (63.55 %) make the choice of their seeds from their old stocks. This is by sorting grains with higher phenotype and quality from the stock. In the two study areas, two cultivars of peanut are essentially cropped: the local variety commonly known as <<MOTO>> (85 %) and the improved variety designated as << CADER >> (15 %). However, it is not uncommon to see fields of local peanut variety with random introduction of some improved varieties. According to the perception of peanut producers, improved varieties are more productive and produce more oil (90 %) than local varieties especially when climatic conditions are encouraging. However, these two varieties belong to the '*Spanish*' group which is one of the most encountered groups in West Africa. Nevertheless, a few assertions of "*Valencia*" and "*Virginia*"

groups are met from location to location.

The majority of peanut producer's (98.05 %) have no easy access to formal and/or informal loans for financing agriculture in general and for the cultivation of peanut in particular. This is more remarkable in the north.

Table 5: *Production factors of Peanut*

Variable	**Modality**	**Percentage of Respondents (%)**	
		North (n= 103)	Center (n=100)
User Access to land	Heritage	60.2	46
	Purchase-sharecropping	1	43
	Donation	35.9	0
Seed Acquisition Mode	Sample in crops	64.1	63
	Buy Market	21.4	25
Agricultural Equipment Level	Hoe	8.7	50
	Daba	11.7	50
	Tractor	79.6	0
Obtaining financing	Yes	1.9	2
	No	98.1	98
Labor	Paid worker	94.2	30
	Domestic	5.8	70

Techniques of peanut production

Table 6 presents the cropping practices for peanut production. The analysis of the results shows that peanut cropping starts always by plowing (99 %). So in the north, producers prefer flat plowing (76.7 %) while in the center, all producers prefer plowing in ridges. Two seeding modes are recorded: direct seeding and seeding on the fly. Direct seeding is the most practiced mode by the majority of producers (99 %). Thought it is recommended 11.1 plants per m^2 or 111.000 plants per hectare, one observes in the north that the majority of producers (50.5 %) often practice about 125.000 plants per hectare. Unlike producers of the North, those of the Center practice the mean density of 83.333 plants per hectare. It appears from table 6 that most surveyed producers do not respect the recommended techniques of clearance. Very few producers (12 %) are using two kinds of herbicides (Kalach 360 SL by 60% of producers and Callifor - G 560 SC by 40 % of producers) for weed control.

For soil fertility management, the contribution of organic fertilizers or manure is very little within the two study areas. However, in the Center, the majority of producers (56 %) bury crop residues in the fields against 40 % in the North. In addition, the fallen leaves of peanuts are collected and stored for livestock feeding in the North. With regard to the contribution of mineral fertilizers, the majority of northern producers (51.1 %) practice these techniques. Synthetic fertilizers including 'cottons' fertilizers (NPKSB 14-23-14-5-1) and urea (46 % N) are applied at a dose of 150 kg/ha. The results indicate that only 10 % of producers apply urea. Some producers (20.5 %)

think that fertilizer inputs would contribute to the increase in the production of leaves to the detriment of nuts.

Concerning pest management, the majority of peanut producers (97 %) do not use neither chemical nor organic pesticides, and do not apply any phytosanitary treatment on peanut. The chemical pesticides currently used are Masta, Kerme K, and Bata.

Table 6: Cropping practices of peanut producers in both agro-ecological zones

Variables	Modality	Percentage of Respondents (%)	
		North (n= 103)	Center (n=100)
Preparation Soil	Burn	1	0
	Plowing	99	100
Density seedlings (plants/ha)	125000	50.5	-
	122222	29.1	-
	83333	6.8	58
	62500	1	38
Management of Soil Fertility	Organic matter intake	2.9	1
	Mineral Fertilizers contributed	51.5	7
Managing Weeds	Herbicides	14.6	10

Peanut cropping systems

The majority of peanut producers (90 %) are involved in livestock rearing. Peanut crop ranks third after Yam and corn in the North (13.6 %) and second after corn in the Center (23 %) (Figure 2).The reasons for its cropping are essentially related to its importance in the income of the household (68 %), its easy cultivation (14 %) and for family food needs.

More than 80 % of surveyed producers do not combine peanut crop to other crops in the two surveyed areas. It is mono-cropped but sometimes is mix-cropped with soybean or sorghum (50 %) in the North. In the Center it commonly is in mix-cropping with corn (70 %), yam (10 %) or cassava (10 %). The benefits of these mix-cropping, according to peasant perception, are as follows: good occupation of the agricultural space, diversification of production, multiple sources of income and easy field maintenance.

With regard to crop rotations, these are practiced by the majority of producers (88.3 % in the North and 55 % in the Center). The rotation schemes vary from one area to the other. In the North, various cropping systems are: peanut-soy-peanut (50 % of practitioners), peanut-soya-maize-peanut (40 %) and peanut-sorghum-soybean-peanut (8 %). In the Center, crop rotations are peanut-soy-peanut (65 %) and peanut-cassava-peanut (15 %). It appears from our results that the peanut is still rotating head regardless of the area. Similarly, the practice of fallowing is not common (95 %) in the two study areas. According to the perception of producers, fallow is not practiced due to the lack of available space, but also because crop rotations

contribute to soil fertility improvements.

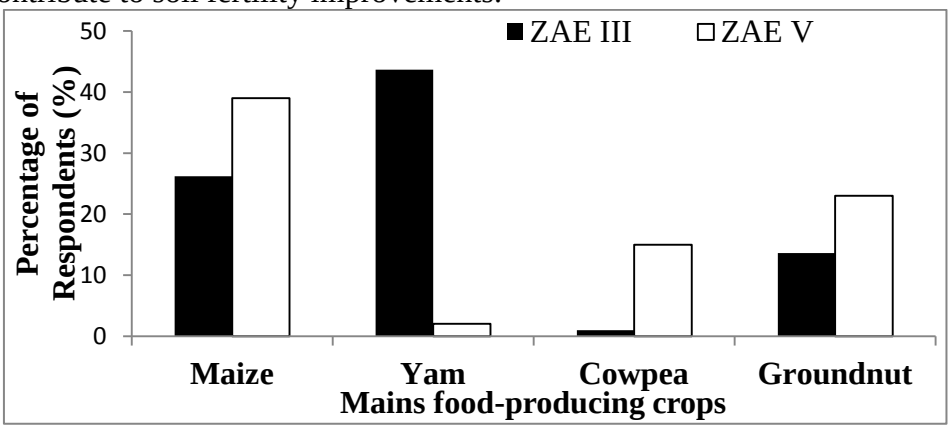
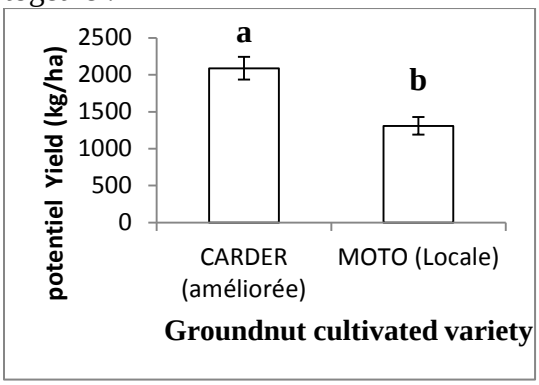
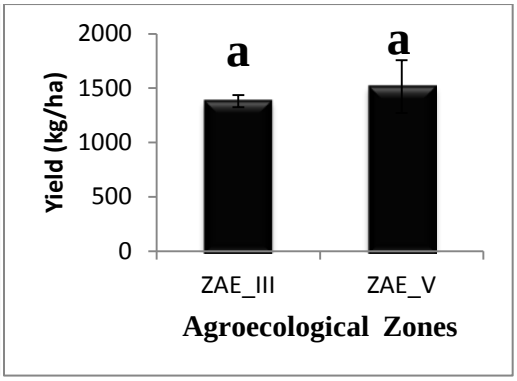


Figure 2: Mains crops according to respondents in the two study area

Level of performance of peanut production in two areas

The results of the analysis of variance show that there is a significant ($P < 0.05$) difference between the potential yields of the two peanut cultivars in the two agro-ecological zones (Figure 3). The improved variety "CARDER" potential yields are significantly higher (2087.68 ± 154.06 kg/ha) than those of the local variety "MOTO" (1309.38±119.25 kg/ha). However, no significant differences ($P > 0.05$) exist between the two areas of production with respect to yields obtained in the year 2013-2014 (Figure 4). Average yields achieved in rural areas for peanut are 1380.13 ±56.64 kg/ha in the North and 1512.76 ± 242.97 kg/ha in the Center for the two varieties together.





Vertical bars denote standard errors. Bars of the same types labeled with the same letter are not significantly ($P > 0.05$) different according to the Student Newman-Keuls test.

Figure 3: Potential yield of both cultivars of Peanut

Figure 4: Yield obtained in 2013-2014 agricultural season

Production and marketing constraints

The results show that after harvesting peanuts, the majority of producers (99 %) dry their produce. The later is stored in bags of 100 kg

capacity. No product conservation means are used within 5-6 months (80 %) before selling in lean season. More than 70 % of producers prefer selling their produce to retailers because of their proximity to fields or storage areas. The major production constraints listed by the majority of producers (85 %) are: poor seed quality, lack of specific inputs, lack of financial resources, lack of manpower and the climatic hazards, mainly the pockets of drought, the poor distribution of rainfall and the excessive temperatures. Strategies developed by producers in order to face these constraints are summed up in the installation of a few feet of cashew in the fields. The revenues generated per hectare by the sales of peanuts can reach 300.000 fcfa to 400.000 fcfa (55 % of producers). These revenues are used in the education of children, for the needs of the household and as grants to other agricultural activities. During wedding, the peanut bag of 100 kg can be sold up to 20.000 CFA.

Integration of peanut crop in breeding

Table 7 presents the main factors of peanut crop integration in farming. In both study areas, the majority of peanut producers (60%) do not feed animals with peanut dead leaves neither in food supplementation nor as forage. However, a great size of the Northern producers supply their cattle with peanut fallen leaves in dry season. More than 70 % of the surveyed producers do breed their animals in divagation inducing the inability to store animals' dejections. This should be added to the fact that farmers prefer to throw dejections because of its transport costs. The types of animals reared are variable with a predominance of goats and sheep (~ 5 heads /producer).

Tableau 7: Integration factors of peanut production and breeding stock

Variables	Modality	Percentage of Respondents (%)	
		North (n=103)	Center (n=100)
Part of the peanut plant given to animals	Fallen	26.2	3
	Any	73.8	95
Animals Breeding	Yes	68.9	52
	No	31.1	48
Livestock Type	Confinement	1	14
	Divagation	99	86
Food Supplements	Yes	23.3	10
	No	76.7	90
Conservation of residue peanut fallen	Any method	75.7	98
	As hay	9.7	2
	Open Storage	9.7	0

Discussions

Economic and demographic characteristics of peanut producers

The majority of peanut producers' are male and are between 16 and 73 years old with an average of 38 years in the two areas. They are not educated in general. More than half of the surveyed producers have over 10

years of experience in peanut production. Households have an average of four dependents and cultivated peanut areas per household are less than 2 ha. Very few producers are members of a peasant association. Similar results are also obtained by Naitormbaide (2007) from the producers of peanut in the regions of Nguétté 1 and Gang in Chad. This situation reflects the fact that peanut cultivation is mostly practiced by young people. According to Balogoun *et al.* (2014), younger strata of population have access to available land in the long term for the perennial species. This therefore justifies their passion to annual crops including peanut. This result could be also explained by the fact that peanut is at majority cropped without inputs. The importance of male producers in the cultivation of peanuts is explained by the customary rules which restrict the rights of female actors to land ownership (Saïdou *et al..*, 2007). The same observation is made from producers of Yam in the Northwest of Benin, where women represent 7.33 % of producers with 58 % of illiterates (Loko *et al..*, 2013). According to Bah (2010), producers' illiteracy in general and that of peanut producers' in particular is a major problem in West Africa. In relation to the average area planted for peanuts, cultivated areas are significantly higher ($P < 0.05$) in the Center than in the North. This is at once, explained by the fact that peanut crop is adopted earlier in the Center compared to the North. The average areas of peanut farms, that are around 1.17 ha in the North and 1.77 ha in the Center, are substantially the same as those found by Naitormbaide (2007) at Gang (1.2 ha) but less than those of Nguétté 1 (3.9 ha) region in Chad indicating the importance of peanut crop for producers of those two areas.

Peanut-based production systems

Legacy is one of the dominant modes of land acquisition in the two study areas (55 %). This is followed by land purchases and land donation. The later is mainly observed with women in general the northern part. It is also observed that migrants receive plots from friends or from the head of the village. According to Naitormbaide (2007), land status influences the management of soil fertility. In fact, operators who are not land owners do not virtually invest in land fertility. Yémadjé *et al.* (2012) also show that in Benin, the degree of land security is one of the constraints of sustainable practices in implementing or regenerating soil fertility, as these practices correspond to an investment in labor and/or capital.

More than 80 % of surveyed producers do not combine peanut crop to other crops in the study areas. This is unlike practices that are reported by Nuttens (2001) and Hauswirth and Naitormbaide (2004). In fact, authors reported mix-cropping to safeguard crop yields against bioclimatic hazards (drought, insects etc.) and ensure a minimum level of production. According to Opoku-Ameyaw *et al*. (2003), the benefits of a practice combining annual

crops such as peanut with trees can include food security for households, diversifying income sources, weed control etc. Peanut is mono-cropped but sometimes is mix-cropped with soybean or sorghum (50 %) in the North. In the Center, on the contrary, it is commonly mix-cropped with corn (70 %), yam (10 %) or cassava (10 %). The rationale behind producers' perception of not mix-cropping is as follows: too much pressure on lands, incompatibility of some crop species, good occupation of agricultural lands, reduction of the rate of infestation etc.

Crop rotations are practiced by the majority of producers (70 %). Similarly, the practice of summer fallowing is not common in the study area. Naitormbaide (2007) observes that only 8% of Gang land in Chad is regularly uncropped, for an average duration of 2 years. According to the author, in this area of Tchad, cotton or cowpea comes ahead in the rotation. Peanut-sorghum rotations are stigmatize by several authors. Indeed, they think that it is not conducive of soil conservation in the long term because peanut cultivation requires intensive works. Works such as weeding and digging enhance the process of soil degradation (Morou and Rippstein, 2004). However, in the rotation with peanut where this crop precedes sorghum, sorghum yield is generally high. Experiments carried out by Bado (2002) at Kouaré in Burkina Faso show that the yield of sorghum increases by 155 % when sorghum is preceded by peanut crop. The return of crop residues is still nowadays a constraint to producers (Sossa *et al.*, 2014). According to Penot *et al*. (2015), in Madagascar, the adoption of culture with direct seeding systems and burial of crop residues to compensate erosion and decline in soil fertility while perpetuating the pluvial agriculture (Scopel *et al.*, 2013), has shown some sticking points that may interfere with the social acceptability of these agricultural practices, and may limit its adoption. These constraints are: the status of the land, the low technical capacity of producers and the lack of money for the purchase of inputs.

Tillage techniques practiced by all surveyed producers display some benefits but they also have their perverse effects. Several authors have shown the mixed role of labor. On the one hand, Chopart and Nicou (1980), cited by Naitormbaide (2007), observe that tillage increases up to 20 % the average yields of millet, sorghum, peanuts and cotton. This increase can reach 50 % for corn and 100 % for upland rice. On the other hand, Seguy *et al*. (2001) show that labor could cause physical and chemical soil degradation under certain conditions. According to the authors, on ferralitics soils, the annual average losses due to erosion in carbon in the 0-10 cm horizon is 0.25 kg/ha. It can also lead to the destruction of the soil structure.

Concerning the soil fertility management, the contribution of the organic fertilizers or manure is very little. However, in the Center, the majority of producers bury crop residues in fields. In contrast to the North,

the dead peanuts leaves are collected and stored for livestock feeding. For the mineral fertilizer, the majority of producers of the North practice this contribution and this with regard to the cotton fertilizers for other crops. In fact, according to Morou and Rippstein (2004), in the peanut harvest areas followed by total cleaning fields, this could be detrimental to the regeneration of the humus in regard to the deficit observed in the organic soil amendment. So according to Sossa *et al.* (2014), the cultural technique which consists in making the fields 'clean' by ridding it of any vegetation, bringing chemical fertilizers and without the return of organic matter, subject the land and the environment to a rapid and irreversible degradation. Several authors (Pichot *et al.*, 1981; Berger *et al.*, 1987; Sedogo, 1981; Bationo and Mokwunye, 1991; Bado *et al,.* 1997) also show that on the West-African soils, culturing induces a systematic decrease of soil organic matter and also a decrease of yields (Babo, 2002). According to Babo (2002), although peanut enriches soil by fixing atmospheric nitrogen (8 to 23 kg N ha), the current practice of promoting peanut cultivation could be a factor of soil impoverishment, because mineral exports are scarcely offset, where long fallows could sufficiently ensure the natural regeneration of soil fertility .

The peanut potential yields, according to the producers, vary from one zone to another but there is no significant difference ($P > 0.05$) between the yields obtained in the field by the producers. Similar results are obtained by Raimi, (2013) with improved varieties purchased through SONAPRA (Benin National Society for the agricultural Promotion) (1800 kg/ha) at Zangnanado (Benin) in a rotation system corn-cotton-peanut. The average yields in the two areas are approximately 1400 kg/ha. This result is greater than those observed in Africa in general (1 t/ha) but lower than those obtained in Asia (1.8 t/ha) and United States (3 t/ha) (Garba *et al.*, 2015). This difference in result could be explained in general, by the peasant culture of peanut management practices characterized by very low planting densities 62,500 to 83,333 plants per hectare instead of 11.1 plants per m^2 (Adjahossou *et al.*, 2009), allowing an improvement of the performance level in Benin. The absence of significant difference between the yields obtained in the two areas could be justified by the fact that the decomposition of crop residues in soils of the Center releases nutrients that come to offset the contribution of mineral fertilizers in the North. This is also explained by the fact that peanut production practices in the two areas are equivalent (Balogoun *al.*, 2014). However, there is sometimes a gap between peasant declaration and the results of an experiment. Indeed, Naitormbaide (2007) claims yields of about 3 t/ha while the average obtained by producers is 965 kg/ha in the Savannah belt of Tchad. Such a situation could be explained by the collection of reliable data through the experiment device.

Unlike Revoredo and Fletcher (2002) who show that peanut is also

used for animal feeding in most of Sahelian countries where leaves, after harvest, are dried for animal feeding, very few producers in this study use this practice. This observation could be linked to the cost of dead leaves transport. It can be explained by the fact that producers think to restore the fertility of their soil by burying fallen leaves in the soil.

Conclusion

Peanut production is a very important economic activity for the producers in the study areas. It is an income generating crop as well as one that ensures food security. Peanut production techniques vary in the study areas. Peanut is mono-cropped in general. Nevertheless, producers combine this crop with several annual crops such as yam in the North. One characteristic feature of agriculture in the study areas is subsistence. It is specifically marked by weak organic and inorganic inputs for peanut production. The current trends in terms of agricultural intensification are very damaging with long term risks on land resource conservation. Manure from peanut crop can hardly compensate extracted minerals. There is then the need to identify an appropriate leguminous plant-based rotation in which crop yields are not the sole adoption criteria, but also quantities of manure.

The main constraints of peanut production in these different study areas are poor quality seeds, lack of specific inputs, lack of financial resources, lack of labor and bioclimatic hazards. Research and development should address all those constraints if sustainable leguminous plant based production systems were to be promoted.

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