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Climate change and cashew (*Anacardium occidentale* L.) productivity in Benin (West Africa) : perceptions and endogenous measures of adaptation

D. O. BELLO[1,2,3*], L. E. AHOTON[1], A. SAIDOU[2], I. P.B. AKPONIKPÈ[3], V. A. EZIN[1], I. BALOGOUN[2] and N. AHO[1]

[1]*Laboratory of Plant Biology, School of Science and Technique of Crop Production, Faculty of Agronomic Sciences, University of Abomey-Calavi, 01 BP 526 Cotonou, Benin.*
[2]*Integrated Soil and Crop Management Research Unit, Laboratory of Soil Sciences, School of Science and Technic of Crop Production, Faculty of Agronomic Sciences, University of Abomey-Calavi, 01 BP 526 Cotonou, Benin.*
[3]*Unit of Soil Physics and Environmental Hydraulics (SPEH), University of Parakou, BP 123 Parakou, Benin.*
[*] *Corresponding author; E-mail: bello.daouda@yahoo.fr; Tel: +229 96302675*

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ABSTRACT

This study aimed at analyzing the perceptions of cashew producers of the climate change, climate change effect on cashew productivity and to identify the adaptation strategies developed to mitigate them, two hundred and seventeen (217) cashew producers older than 50 with more than 10 years experience in cashew plantation were selected randomly from 20 villages. In each of the selected villages, the data were collected using questionnaires, individual and group interviews and fields visit. The collected data were socio-demographic characteristics of the households (sex, age, household size, education level, years of experience in the cultivation of cashew, types of the men size of household laborer used, farm size), perceptions of cashew producers in relation to indicators of climate change, and climatic factors that influence the productivity of cashew and especially the various strategies developed to adapt to. These data have been submitted to descriptive statistic, analysis of variance and multivariate analysis. The results this study indicate that the producers of the Central parts of the country were significantly older and more experienced ($P<0.05$ to $P<0.0001$) when compared to producers from other areas. The lowest of cashew plantation area were recorded in the North-East despite the availability of cultivable lands ($P <0.0001$). The producers have reported an increase in temperature and decrease in rainfall and the occurrence of violent winds from time to time. The high rates of dried flowers and yield losses were the new climate change indicators identified in the study. Mulching (71.80%), manure application (7.8%) and regular management of plantations (6%) were the main strategies developed. The number of household laborer, the experience of the producer, determined significantly ($P < 0.05$ to $P <0.0001$), the choice of the adaptation measures to climate change. We recommend to assess the efficacy of these strategies for sustainable cashew production.

Keywords: Adaptation strategies, Benin, cashew tree, climate change, farmers perceptions, yield.

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INTRODUCTION

The world has been experiencing a dramatic change, especially in the last few decades (Oguntunde et al., 2014). Although the nature and extent of the changes cannot be accurately quantified, the experts of the Inter-governemental Panel on Climate Change (IPCC) are unanimous on the impact of this phenomenon which is nowadays perceptible in all regions of the world (Tidjani and Akponikpè, 2012). According to Dugué (2012), the global climate change is expressed locally through many evolutions that modify the conditions of production, namely: i) the shift in climate calendars (delay in the beginning of rains in particular); ii) the changes in rainfall amount received annually in many regions, coupled with drought spells which becomes longer more frequent; iii) the increased frequency of extreme phenomena and abnormal events (hurricanes, frosts, unusually high temperatures); iv) a very high temporal and spatial variability at the local level. Benin is known for more than 40 years as a country of high climatic variability characterized by fluctuation of period and duration of rainfall, variation in annual rainfall, an increasingly hot climate, drought, degradation of soils, unexpected floods, high winds and pest and disease proliferation (Yabi et Afouda, 2012). The diagnosis of climate change effects shows that the agro-ecological zones of the central and northern Benin are the most vulnerable to climate risks: drought, late and heavy rains and floods (Yaï et al., 2014). According to Boko et al. (2007), climate change has a direct impact on agricultural production, since agricultural systems depend on the nature of the climate. This impact is particularly important in developing countries where agriculture is the main source of employment and income for the majority of the population (Entete et Onyekuru, 2011).

In Benin, two large areas are very suitable for cashew growing namely the Guinean zone and the Sudano-Guinean zones. The cashew sector represents for the country a great opportunity for agricultural export, after cotton crop (Tandjiékpon, 2010; Yabi et al., 2013; Balogoun et al., 2014). The country ranked globally sixth in 2011 with roughly 3.8% of volume of nuts produced and third among West African countries after Nigeria and Côte d'Ivoire (FAO, 2014). Cotton, that was always the first agricultural export, was supplanted by cashew in 2008, thereby ranked 1st among agricultural products export in Benin (Tandjiékpon 2010). The study on the characterization of the cashew production systems in the main growing areas carried out by Balogoun et al. (2014), revealed that the main constraints to the development of the cashew sector in Benin include climatic conditions which are characterized by scarcity and poor distribution of rainfall, harmattan with dry winds and low temperatures. The authors mentioned that climate variability causes drying, abortion and the fall of flowers, leaves and even fruits, thus reducing productivity. It is therefore urgent to adopt adaptation measures and develop new strategies to avoid the worst effects of climate change (Willbanks et al., 2007), notably on cashew trees in Benin.

The most effective and sustainable adaptation measures are often those taken at the local level by directly involving those concerned stakeholders. Adaptation practices developed by farmers in response to the negative consequences of climate change depend on the perception and endogenous knowledge they have of climate and changes (Dimon 2008). It is evident that farmers knowledge has become inescapable for their adaptability to the agro-ecological and social contexts and their accessibility for resource-poor farmers (Mbow et al., 2009). Taking into consideration this knowledge although empirical in the development policy could boost farmers' confidence (Bambara et al., 2013). To manage the negative effects of climate change on cashew tree, it is essential to define the relevant adaptation based on those developed locally. According to Moustapha et al. (2012), adaptation is a process that initially requires that producers are aware of the fact that the climate has changed and then identify the necessary measures to implement. The present study aimed at analyzing the perceptions of cashew producers on the effects of climate change on cashew trees and at identifying the strategies developed by producers to manage those adverse effects.

MATERIALS AND METHODS

Study area

This study was conducted in eight Districts of Benin Republic (Figure 1). The choice of these Districts was based on zoning favorable to cashew production as described by Tandjiekpon (2010). According to the author, cashew is planted in four areas in Benin, namely the high production zone (where the cashew growing has not particular problem because of favorable climatic and geomorphological conditions), located primarily in the Department of Collins and the Southern parts of Borgou Departement, the medium production zone (where climatic conditions do not allow the expression of the productive potential of the cashew tree), represented by North Borgou, North Donga and South of Collins Department, the low production zone (hardly favorable to limited area), stood for Zou and Plateau Department, and southern Alibori and the marginal production zone (where climatic and geomorphological conditions are not favour to the development of the cashew tree) accounted for extreme north and extreme south of Benin. Thus, Glazoué, Savè and Bantè districts in the Collines department were selected in the high production area. It is a transition zone (between South and North) of 16,900 km² extending after the plateaus of Abomey and Kétou til the 9th parallel north (Balogoun et al., 2014). The district of Djougou in Donga the department (Northwest Area) was selected as medium production area. The Northwestern parts of Benin are essentially of a mountain climate with slight variations from one locality to another. These soils are of fine clay-sandy texture. Lateritic and hydromorphic soils were also observed in these areas (INRAB, 1995). Districts of Djidja and Bohicon in the South and Gogounou and Kandi in the North East were chosen as low production area. The Districts of Gogounou and Kandi in the department of Alibori (North East Zone) also belong to the Sudanese zone and the relative humidity can reach 80% during the cropping season but can decrease until 35% in the dry season. The Districts of Bohicon and Djidja, are characterized by bimodal rainfall and relative humidity between 69 and 97%. The characteristic of each area are presented in Table 1.

Choice of surveyed villages

The criteria relating to farming techniques (cashew plantation management, interest in the crop, intercropping, etc.), perception of climate change effects and the adoption or the non-adoption of an adaptation strategy by the producer were of paramount importance in the selection of the surveyed villages. Land availability, accessibility of the zone at all season and open-minded producers to collaborate with the research team and the socio-cultural group was the additional criteria used. On this basis, 20 villages were selected (Table 1). Before the in-depth survey, an exploratory study was conducted in August 2014 so as to have an overview on the perceptions of producers of climatic variability to reorient the questionnaire of the study.

Sampling method

The sample size (N) was obtained using the normal approximation of the binomial distribution proposed by Dagnelie (1986):

$$\mathbf{N} = \left[\left(\mathbf{U}_{\mathbf{1}-\frac{\alpha}{2}}\right)^{\mathbf{2}} \times \mathbf{p}(\mathbf{1}-\mathbf{p})\right]/\mathbf{d}^{\mathbf{2}}$$

Where:

U_1-α $/_2$ is the value of the normal random variable of probability value of $_1$-α $/_2$, α is the error risk. For α = 6% (1% ≤ d ≤ 15%), the probability $_1$-α/$_2$ = 0.975 and thus U_1-α $/_2$ = 1.96. P is the proportion of cashew producers with age more than or equal to 50 years with more than ten years of experience and who are always in cashew production in the study area and the margin of estimation error, which was 6% in this study. From the p values of the exploratory phase results obtained, a total of 217 producers were selected in the study area as follows: 108 producers in the low production area, 39 in the medium production zone and 70 in high production area. They were chosen according to the size of cultivated areas for cashew production. In each area, the respondents were identified by simple random sampling.

Methods and data collection tools

The cashew producers with age ≥ 50 years per village were identified after a focus groups discussion. But in the case of our study, the respondents were producers who can still remember things vividly and above all continued to manage their plantations. The individual survey was conducted using the method described by Balogoun et al. (2016), involving 217 producers with at least 10 years of experience in cashew production. In each of the selected villages, the data were collected using questionnaires, individual and group interviews and visit of fields (Kombo et al., 2012). The collected data were socio-demographic characteristics of the households (sex, age, household size, education level, years of experience in the cultivation of cashew, types of the men size of household laborer used, farm size), perceptions of cashew producers in relation to indicators of climate change, and climatic factors influencing the productivity of cashew and especially the various strategies developed to adapt to. These climatic events were related to rainfall, wind, ambient temperature, sunlight duration, etc. The real cultivated area considered were those corrected by the difference obtained between the declared values and those measured with GPS Garmin eTrex 20 from a sample of five producers per locality (Balogoun et al., 2014).

Data analysis

Exploratory analysis

The collected data were codified, entered and analyzed using SPSS (Statistical Package for Social Sciences) Version 20.0 (Norusis, 2002), for determining descriptive statistics in terms of percentage and mean. Quantitative data (age of cashew producers, experience in cashew production, cashew tree area, average age of plantations, etc), were then subjected to analysis of variance (ANOVA) using PROC GLM procedure of SAS (Statistical Analysis System) Version 9.2. The Student Newman-Keuls test was used for mean separation considering 5% level of probability (Dagnelie, 1986).

Perceptions and Adaptations trajectories

In Benin and generally in Africa, local perceptions of events and practices are influenced by ways and customs, which are dependent on sociocultural groups (Gnanglè et al., 2011). Therefore, the respondents were grouped according to the eight main socio-cultural groups, namely Fon, Tchabè, Itcha and Idaatcha, mostly represented in the Guinean and Sudano-Guinean areas and Bariba, Dendi, Yom and Lokpa (in the Sudanese zones). In each group, respondents were grouped into two age categories (adult i.e 50-70 years, elders, i.e 70 and above) and sex (Assogbadjo et al., 2008). Thus, in total, 23 socio-cultural categories (instead of 32 potentials) and taking into account the combination of main socio-cultural groups, age and sex were considered (Table 2).

For each person surveyed, the perception citation for each indicator of climate change was determined. For each of the 23 categories, an average of perception citation was calculated for each indicator from the average value of the citation of perception of this indicator by the individuals in the group considered. A matrix of perception of indicators of climate change and its effect on the cashew was subjected to Principal Component Analysis (PCA) according to Uguru et al. (2011) and Sossa et al. (2014). A similar analytical approach related to the establishment of socio-cultural groups was performed for the adaptation of producers in relation to climate change. For each group, the number of people opting for each adaptation strategies identified was calculated. The contingency table obtained was subjected to simple correspondence factorial analysis (CFA).

Determinants of adaptation strategies

To determine the factors that influenced the decision of cashew growers to develop adaptation strategies to the climatic variability, the binary logistic regression was used in the following model (Nabikolo et al., 2012):

$$\boldsymbol{Yi = xi\beta + \varepsilon i}$$

Where, $\boldsymbol{Yi}$ represents a dichotomic dependent variable (the variable was set to 1 if the producer adopts an adaptation strategy in response to climate change and 0 otherwise), $\boldsymbol{xi}$ was the overall explanatory variables and $\boldsymbol{\varepsilon i}$ was the standard error. The explanatory variables considered were among those reported by several authors (Oyekale et Oladele, 2012; Loko et al., 2013) as affecting the producers of not being aware of the climate change.

Table 1: Characteristic of each area and surveyed villages according to socio-cultural groups.

Cashew production area	Season plus mean rainfall	Mean Temperature	Soil	Department	Region	Climate	Surveyed Districts	Surveyed Villages	Socio cultural group
High	- Two rainy seasons from April to July and October to November. - Rainfall: 1.100 mm per year	Between 24 and 29°C.	Leached tropical ferruginous soils or improvised soils	Collines	Centre	Sudano-Guinean	Savè	Gobé	Tchabè-Idaatcha
							Glazoué	Kpakpaza Yawa Kpakpazoumè	Idaatcha Idaatcha Idaatcha
							Bantè	Gbégamey	Itcha
Medium	- A rainy season from April to October - Mean rainfall: between 1200 et 1300 mm	Between 25.29 and 30.76 °C	Tropical ferruginous soils	Donga	North-west	Sudano-Guinean (between the 9th and the 10th parallel north)	Djougou	Founga Kamourou	Yom-Lokpa Yom
Low	-A rainy season from May to October, - Mean rainfall : between 800 and 1.300mm per year	Between 25.29 and 30.76 °C	Tropical ferruginous soils	Alibori	North East	Sudano-Guinean	Gogounou	Kanta kpara Soukarou Gounarou Fana	Bariba Bariba Bariba Bariba
						Sudanese (between the 9th and the 10th parallel north)	Kandi	Kpèdè Kassakou Kandi 1	Bariba-Dendi Bariba Bariba
	bimodal rainfall with an annual average of 1200 mm per year.	Between 25 and 32 ° C	Either lateritic and deep or rich in vertisols, humus and minerals	Zou	South	Sub-equatorial tending to Sudano-Guinean (6°25'-7°30'N)	Bohicon	Tovigomè Avogbana	Fon Fon
							Djidja	Agondokpoé Monsourou Ahozoun Kingbé	Fon Fon Fon Fon

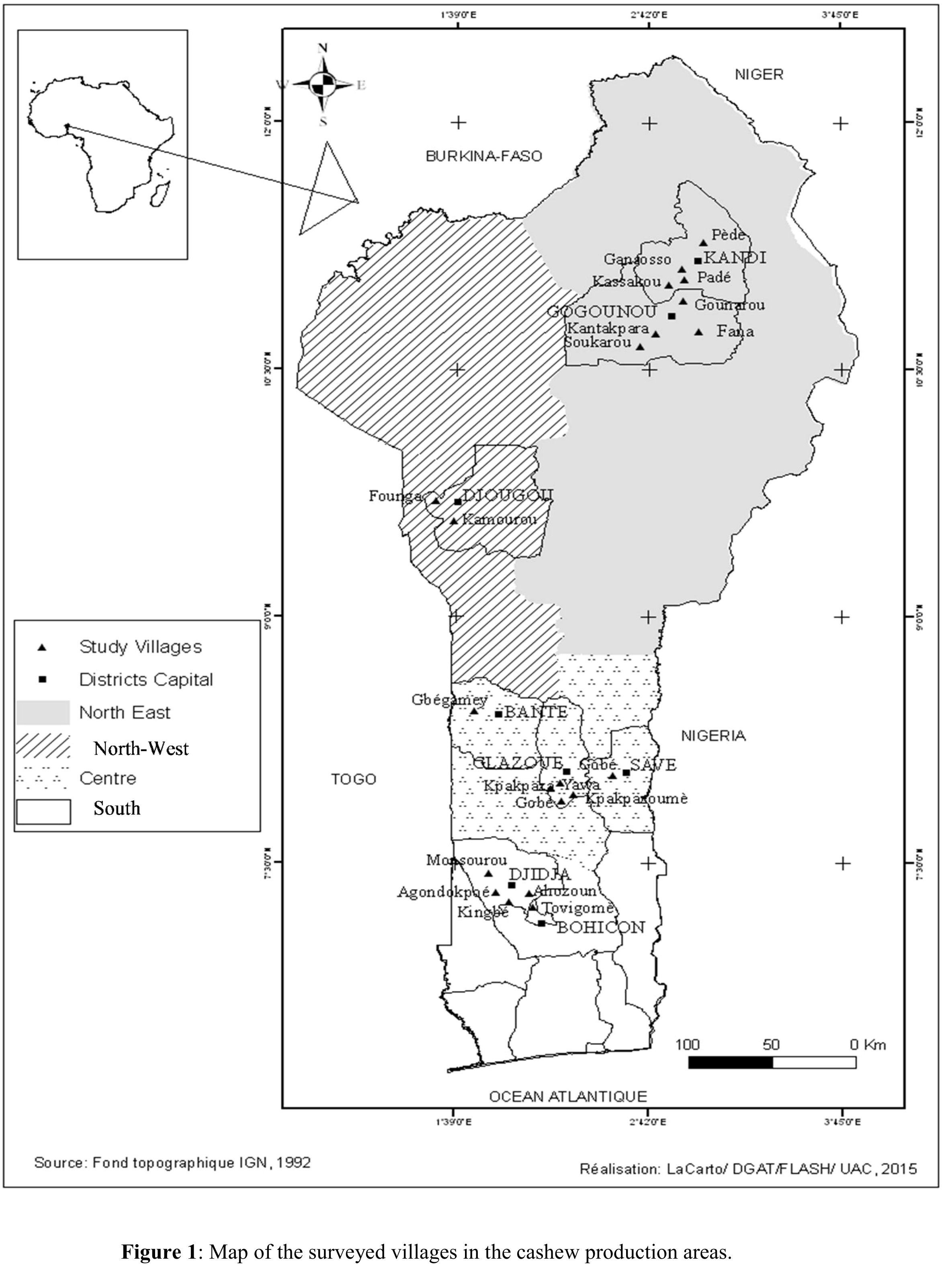

Figure 1: Map of the surveyed villages in the cashew production areas.

Table 2: Number associated with the 23 main socio-cultural groups studied (N = 217).

Socio-cultural groups	**Codes**	**Number of producers**
Adult Woman Bariba	AWB	04
Adult Woman Fon	AWF	11
Adult Woman Idaatcha	AWI	7
Adult Woman Itcha	AWIt	04
Adult Woman Yom	AWY	01
Adult Man Bariba	AMB	44
Adult Man Dendi	AMD	02
Adult Man Fon	AMF	33
Adult Man Idaatcha	AMI	32
Adult Man Itcha	AMIt	05
Adult Man Lokpa	AML	02
Adult Man Tchabe	AMT	02
Adult Man Yom	AMY	34
Old Woman Fon	OWF	07
Old Woman Idaatcha	OWI	02
Old Woman Itcha	OWIt	01
Old Man Bariba	OMB	03
Old Man Dendi	OMD	01
Old Man Fon	OMF	04
Old Man Idaatcha	OMI	09
Old Man Tchabe	OMT	01
Old Man Yom	OMY	02
Old Man Itcha	OMIt	05
Total		**217**

RESULTS

Socio-economic characteristics of cashew producers

Table 3 presents the results of the descriptive analysis of socio-economic variables of cashew producers in the three production zones surveyed in Benin. In general, men grew more cashew trees than women (83.3% against 16.7%). In all of the study areas, the age of the surveyed producers ranged from 50 to 90 years with an average of 59.81 years. The analysis of variance and the Student Newman Keuls test showed that producers residing in the center (high production area) were much significantly (P <0.01) older than those of the other two production areas (Table 4). It appears that the age of the majority of the respondents (86.3%) was between 50 and 70, and the majority of the cashew growers were also married (84.1%). The majority of the plantations were owned by local residents (98.8%), and most of them were not educated (75.5%). The majority of respondents had between 10 and

20 years of experience in the management of plantations in the low and medium production areas (71.7%) whereas they had over 20 years of experience in the high production area (70%). The number of experience years in the cultivation of cashew was highly significant (P <0.0001) in the high production area (Central zone). The least experienced respondents was recorded in the North West (medium production area) (Table 3). In the fair production area and average production zones (South and East; North West), the cashew cultivation area was less than 3 ha (58.6% and 73.2% respectively), whereas it was higher than 3 ha for most of the producers in the Centre (74.4%). The results also revealed that the available areas and those exploited were significantly higher (P < 0.0001) in the fair than in the central parts of the country (Table 4). Similarly, the results also showed that the number of agricultural manpower was highly significant in the South and Northeast (P <0.0001) when compared with the Centre. This indicates the importance given to the cultivation of other crops to the detriment of cashew tree, due to unfavorable climatic conditions to cashew production in both regions. However, the income generated from cashew production helps growers supplying the need of their family and provides a peaceful retirement the retirees who are engaged in cashew production.

Cashew producers perception on climate change and climate factors affecting production of cashew

The view of cashew producers on the indicators of climate change, and climatic factors which affect the production of cashew are shown in Table 5. The results indicate that local perceptions were generally unanimous on the irregularity of rains, high winds, high rate of drying of cashew flowers during seasons as indicators of climate change in all the surveyed areas. However, Bariba and Dendi producers in the low production area did not associate the decrease in the production of cashew with an indicator of climate change but rather the increase in temperature. Perceptions related to changes in other climatic events differed from one cultural group to another. Similarly, climate change indicators also varied according to age and sex. The elder producers seem better perceived the irregularity of rains , high rates of dried flowers and a significant decrease in production as indicators while the adults just observed the increase in air temperature and wind speed. According to the criterion of sex, women (70%) perceived an increase in ambient temperature, high rates of dried flowers and a significant decreasing in production when compared with men (Table 5). As for the factors affecting the performance of the cashew tree, the analysis of Table 5 shows local perceptions on the reduction in rainfall (95%), increase in temperature (80%) and high winds (98%). However, it is noted that in the high production area (Tchabè, Itcha and Idaatcha) apart from rainfall and violent winds, the low productivity recorded was due to low temperatures (66%). On the other hand, age seems, not to influence the perceptions of the effect of climatic factors on the cashew tree except low temperature during harmattan, according to elders as affecting the yield of cashew. According to the criterion of sex, the same trends were observed.

The results of principal component analysis performed on perceptions of data highlighted the relationships between climate change indicators. These results indicate that the first two axes accounted for 64.4% of the total information (Table 6). The first principal component opposed the decrease in cashew tree yield to other climatic events namely, violent winds, increase temperatures, and high rate of dried flowers (Figure 2, Table 7). According to the cashew producers surveyed, an increase in ambient temperature combined with violent winds with high rate of dried cashew flowers during the growing season were often associated with a decrease in the yield of cashew tree (Table 7, PC1).

The projection of 23 socio-cultural categories (Table 2) in the system of axes defined by climatic events (Figure 2) revealed that men and women (adult and elder) producers of Bariba and Dendi socio-cultural groups belonging to the Sudanese zone had the perception that high temperatures, violent winds and high rate of dried flowers were the most important indicators of climate change in their communities. Similarly, these socio-cultural groups believed that the decrease in the amount of rainfall and high temperatures were the climatic factors that affected the yield of the cashew trees. The men and women (adult and elder) cashew producers of Yom, Lokpa and Itcha socio-cultural groups, who lived in the medium production zone believed that the high rate of dried flowers every year, the irregularity of rains and violent winds were important indicators of climate change. These same groups perceived that the delay in the start of rain, violent winds and low temperatures were the climatic factors that affected the productivity of cashew. As for the other socio-cultural groups including the Tchabè, Idaatcha in the high production area (Centre zone) and the producers of sociocultural groups Fon (elders men in particular) in the Guinean zone, were opposed to Bariba and Dendi producers and considered rather mainly the decrease in yields from year to year as the most important indicator of climate change. Likewise, these producers considered that the delay in the start of rain and low temperatures significantly affected the production of cashew. The Idaatcha male producers and the Fon adult female producers opposed the perception of the Yom, Lokpa and Itcha producers. It is noticed that most of surveyed producers (97.25%) were unanimous on irregular rainfall as an indicator of climate change. The results demonstrate that, in general, the reduction in the amount of water, violent winds and temperatures were the main factors identified by the producers as affecting the cashew productivity. This then would affect in the strategies developed by these producers to maintain moisture in the soil and regulate the temperature while cashew tree resist to the effects of violent winds.

Adaptation strategies developed by producers to reduce the impacts of climate change on cashew production in Benin

The investigations revealed that among cashew producers surveyed who recognized the existence of climate variability, 83.4% developed the adaptation strategies that varied with the main effects of climate change reported such as: the reduction of the amount of water, the delay in the beginning of rain, violent winds and high temperature. In response to the decline in rainfall, the delay in the start of rains and high temperature, the surveyed respondents adopted four main strategies (Figure 3) including mulching cashew tree leaves (71.8%), application of manure (7.8%) and regular management of plantations (6%). According to producers, litter stock consisting mainly of cashew leaves were a form of mulch for aged plantations, while for young plantations (<8 years) crop residues associated with cashew were used in addition to cashew leaves as mulch. As for the adverse effects of violent winds, most cashew producers did not adopt any strategy (16.60%). Less than 1.4% use hedges consist mainly of teak (*Tectona grandis* L.) or *Eucalyptus camaldulens* plantations (Figure 3). Although, the decline in soil fertility was not reported as an indicator of climate change, or as a factor affecting the yields of the cashew trees, to maintain soil fertility, only 0.9% of respondents used mineral fertilizers, the association of the cashew tree with legume (1.8%) and other methods (1.4%), including the burying of herbs during plowing and burning of crop residues (Figure 3). New variety of cashew tolerant to climate change were not identified among the adaptations strategies developed by producers.

The results of the Correspondence Factorial Analysis (CFA) realized on the data related to the adaptation of cashew producers illustrated that women and men of Bariba and Dendi socio-cultural groups mostly in the low production area (North-east) used mulching with crop residues and manures (Figure 4). On the other hand, most producers of Tchabè, Itcha and Idaatcha sociocultural groups mainly present in the high production area (Zone Centre), the Yom and Lokpa producers in the medium production area (Northwest) and old producers Fon in the low production area (South zone) used mulching essentially with cashew leaves (Figure 4). Moreover, old men Tchabè and old women Idaatcha applied mineral fertilizer to cashew trees. As for adult producers of Fon socio-cultural groups, they did not adopt any adaptation strategy and prefer to confide in God as climate change appears as inevitable (Figure 4).

Determinants of the adoption of adaptation strategy by producers

Binary logistic regression analysis (Table 6) revealed that among the twelve variables considered, only the experience of the producers, the number of active men in the household, the interest in cashew cultivation and its contribution to the household income significantly influenced ($P< 0.05$) the ability to develop adaptation strategies to the effects of climate change. From the analysis of the table, it appears that the number of active men in the household and the contribution of the cashew tree in household income were the factors that significantly influenced ($P< 0.01$) the adoption of any adaptation strategy while the interest for the cultivation of cashew had a very highly significant influence ($P< 0.0001$). Sex, age, education, origin, marital status of the producer, the number of active women in the household, the area allocated to the cashew plantation and the source of funding of cashew production had no influence on the adoption of adaptation strategy (Table 8). The results indicate that the most experienced cashew producers, with a high interest in the cultivation of cashew and of which cashew plantation highly contributes to their household income were more likely to identify adaptation strategies (Table 8).

Table 3: Socio-economics characteristics of surveyed respondents.

Variables	Modality	Percentage of Respondents (%)			
		Low Production Area (n=108)		Medium Production Area	High Production Area
		South (n=54)[1]	North-East (n=54)[1]	North-West (n=39)[1]	Centre (n=70)[1]
Sex	Male	68.5	92.6	94.9	77.1
	Female	31.5	7.4	5.1	22.9
Age (year)	50years≤ age<70years	83.3	92.6	94 .9	74.3
	age ≥70 years	16.7	7.4	5.1	25.7
Education level	None	79.6	79.6	74.4	68.6
	Primary	11.1	7.4	17.9	22.9
	Secondary	9.3	13.00	7.7	8.6
Marital Situation	Married	75.9	96.3	89.7	74.3
	Widower	24.1	3.7	7.7	24.3
Origine	Native	100	98.1	100	97.1
	Migrant	-	1.9	-	2.8
Expérience in cashew production	between10 and 20years	55.6	85.2	74.4	30.00
	>20 yeras	44.4	14.8	25.6	70.00
Cultivated area available	<3 ha	24.1	0	12.8	8.6
	between 3 and 5ha	27.8	5.6	66.7	44.3
	>5 ha	48.1	94.4	20.7	47.1
Cashew tree area	<3 ha	72.2	74.1	74.4	27.1
	between 3 and 5 ha	18.5	20.4	25.6	58.6
	>5ha	9.3	5.5	-	14.3
Average age of cashew tree plantation	<10 years	13.00	7.4	5.1	4.3
	between 10 and 20 year	77.7	87.00	79.5	48.6
	>20 years	9.3	5.6	15.4	47.1
Reason for cashew tree cultivation	To support a household expenditure	51.9	100	80.5	78.6
	Others	48.1	-	19.5	21.4

[1]Number of Surveyed producers

Table 4: Respondents hosehold caractéristics.

Production area	Age of Cashew Producers (years)	Experience in cashew production	Number of active men in the household	Number of active women in the household	Available area (ha)	Exploited area (ha)	Cashew tree area (ha)	Average age of plantations (years)
High	62.67±1.32a	26.86±1.16a	4.83±0.32b	5.76±0.40b	8.00±0.89b	6.91±0.73b	3.78±0.63a	21.19±0.93a
Medium	58.08±0.93b	16.56±0.93c	5.33±0.45b	5.26±0.48b	4.26±0.32b	4.16±0.33b	2.10±0.21b	15.56±0.83b
Low	58.68±0.68b	19.68±0.78b	7.09±0.37a	9.10±0.61a	15.13±1.58a	12.09±1.06a	2.36±0.25b	14.99±0.43b
Probability	0.0031	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0153	< 0.0001

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

Table 5: Percentage (%) of responses related to indicators of climate change and the effects of climatic factors on the cashew tree according to the cultural group, age and sex.

Percentage of Respondents (%)										
	Climate change indicators					**Climate factors affecting cashew tree productivity**				
Categories	**Rain irregu -larity**	**Violent winds**	**High tempe-rature**	**High rate of dried flowers**	**significant decrease in cashew production**	**Decrea-sein rainfall**	**Delay in rainfall**	**Increased Tempe-rature**	**Decreased Tempe-rature**	**Violent winds**
Cultural groups										
Bariba	100	100	100	100	-	94.1	7.8	98.00	-	100
Dendi	100	100	100	100	-	100	-	100		100
Fon	96.4	30.9	-	1.8	59.9	36.4	29.1	7.3	36.4	89.1
Lokpa	100	50	50	50	50	100	100	50	50	100
Yom	100	69	-	37.9	31.00	34.4	65.5	17.2	82.8	100
Tchabè	66.7	-	-	-	33.3	66.7	66.7	33.3	33.3	66.7
Idaatcha	70.9	16.4	16.70	7.6	29.10	72.7	25.5	7.6	63.6	92.7
Itcha	100	93.3	33.30	53.30	33.30	53.3	46.7	33.3	66.70	100
Age categories										
Adult	90.7	50.3	11.5	3.8	21.9	54.6	30.6	35.5	41.5	95.6
Elder	97.1	41.2	5.9	17.6	44.1	58.8	38.2	14.7	58.8	97.1
Sex										
Man	90.5	61.2	6.8	4.8	16.3	66	31.3	40.8	45.6	99.3
Woman	94.9	41.00	28.2	10.3	43.6	46.2	35.9	15.4	41	92.3

Table 6: Eigen value of the first five principal components.

PC Axis	Eigen values	Proportion	Proportion Cumulated
1	4.7992	0.48	0.48
2	1.6393	0.164	0.644
3	1.13	0.113	0.757
4	0.7788	0.078	0.835
5	0.7557	0.076	0.91

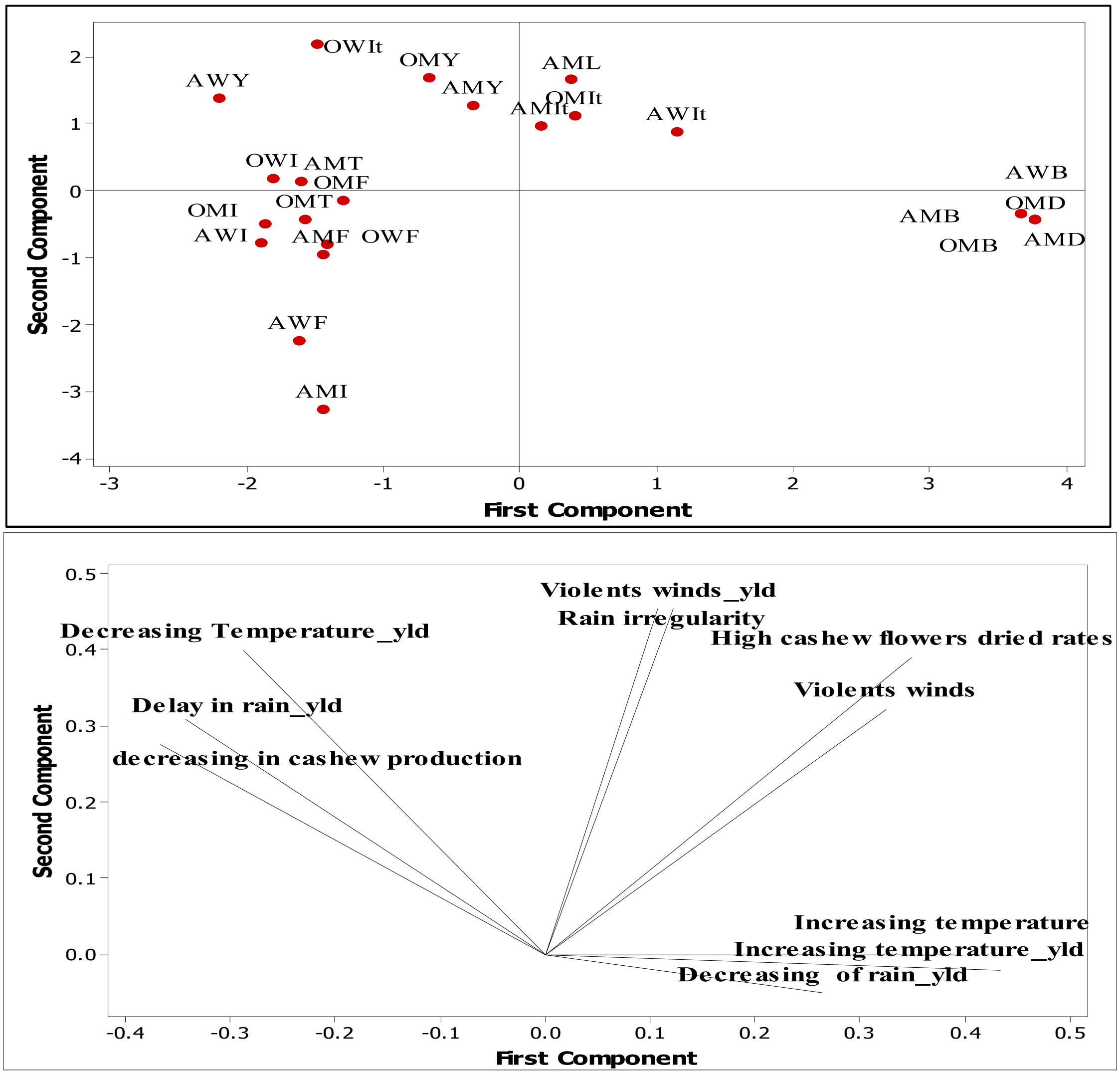

Figure 2: Local perceptions on climate change studied from a Principal Component Analysis (PCA): projection of indicators of climate change and climatic factors affecting cashew and socio-cultural groups in the factorial axis system. AWB=Adult Woman Bariba; AWF = Adult Woman Fon; AWI=Adult Woman Idaatcha; AWIt=Adult Woman Itcha; AWY=Adult Woman Yom; AMB=Adult Man Bariba; AMD=Adult Man Dendi; AMF=Adult Man Fon; AMI=Adult Man Idaatcha; AMIt = Adult Man Itcha; AML=Adult Man Lokpa; AMT=Adult Man Tchabè; AMY=Adult Man Yom; OWF=Old Woman Fon; OWI=Old Woman Idaatcha; OWIt = Old Woman Itcha; OMB= Old Man Bariba; OMD= Old Man Dendi; OMF=Old Man Fon; OMI=Old Man Idaatcha; OMT=Old Man Tchabè; OMY=Old Man Yom; OMIt=Old Man Itcha. The factors with *yld* are witch affecting cashew productivity.

Tableau 7: Correlation between variables and axes.

Variables	PC1	PC2	PC3
Rain irregularity	0.122ns	0.454*	-0.607*
Violents winds	0.324*	0.322*	-0.047ns
Increasing temperature	0.392*	-0.001ns	-0.118ns
High cashew flowers dried rates	0.349*	0.39*	0.062ns
decreasing in cashew production	-0.366*	0.276ns	-0.306*
Decreasing of rain_yld	0.264ns	-0.051ns	0.448*
Delay in rain_yld	-0.344*	0.308*	0.168ns
Increasing temperature_yld	0.434*	-0.021ns	-0.048ns
Decreasing Temperature_yld	-0.287ns	0.398*	0.298ns
Violents winds_yld	0.108ns	0.453*	0.446*

ns= not-significant (P > 0.05); * = significant (P <0.05) ; The factors with *yld* are witch affecting cashew productivity.

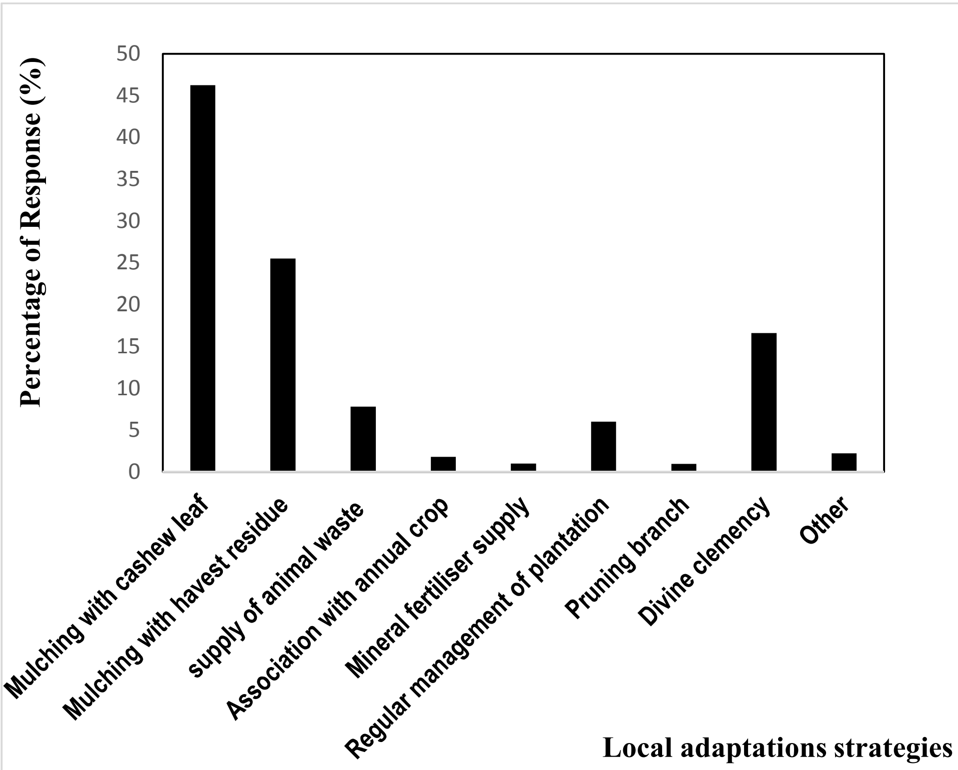

Figure 3: Adaptation strategies in response to climatic variability.

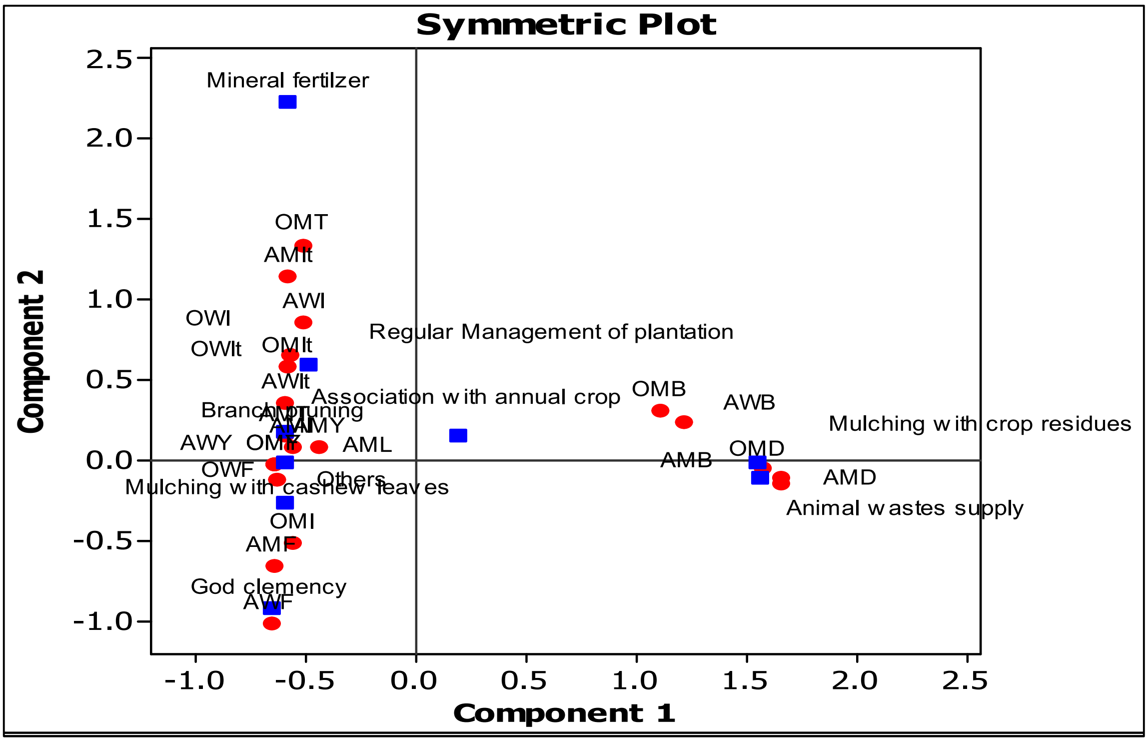

Figure 4: Adaptation to climate change: projections of socio-cultural groups in the factorial axis system after a Correspondence Factorial Analysis (AFC). AWB=Adult Woman Bariba; AWF = Adult Woman Fon; AWI=Adult Woman Idaatcha; AWIt=Adult Woman Itcha; AWY=Adult Woman Yom; AMB=Adult Man Bariba; AMD=Adult Man Dendi; AMF=Adult Man Fon; AMI=Adult Man Idaatcha; AMIt = Adult Man Itcha; AML=Adult Man Lokpa; AMT=Adult Man Tchabè; AMY=Adult Man Yom; OWF=Old Woman Fon; OWI=Old Woman Idaatcha; OWIt = Old Woman Itcha; OMB= Old Man Bariba; OMD= Old Man Dendi; OMF=Old Man Fon; OMI=Old Man Idaatcha; OMT=Old Man Tchabè; OMY=Old Man Yom; OMIt=Old Man Itcha. The factors with *yld* are witch affecting cashew productivity.

Table 8: Determinants of adaptation to climate change by producers.

Independent Variables	Chi-Square	Pr > Chi-Sq
Sex	0.06ns	0.81
Age	0.05ns	0.82
Education level	0.14ns	0.71
Marital situation	0.08ns	0.77
Origin of Producers	1.03ns	0.31
Experience in cashew production	1.44*	0.03
Number of active men in household	8.01**	0.0047
Number of active women in household	0.59ns	0.44
Area allocated to cashew tree	0.16ns	0.69
Contribution to household income	5.98**	0.014
Source of funding	0.01ns	0.92
Interest in cashew production	15.04***	< 0.0001

ns = non-significant (P > 0.05); * = significant (P < 0.05); ** = very significant (P < 0.001); *** = highly significant (P < 0.0001).

DISCUSSION

Socio-economic and demographic characteristics of cashew producers

Men grow more cashew than women in study areas. The age of respondents varied between 50 and 90 years with an average of 59.81 years. Most of respondents had between 10 and 20 years of experience in cashew plantation management in the areas of fair and average production while they had more than 20 years of experience in the high production area. These results are consistent with the findings of many researchers (Lawal et al., 2010; Uwagboe et al., 2010; Balogoun et al., 2014). According to these authors, this reflects the fact that the cashew cultivation remains an activity of old producers whereas young people lack interest in plantations of perennial species. Moreover, according to Tandjiekpon (2005), the difficulties related to the access of the younger ones to the land in the long run or their rural exodus to the urban centers could explain the enthusiasm of old people for growing cashew. According to Saidou et al. (2007), men investment in cashew production compared with women could be explained by the customary rules which restrict the rights of the female to the acquisition of land. According to the respondents, the cashew plantation is done by producers near the age of retirement so that these plantations can ensure a minimum income in the twilight of their lives. The fact that producers living in the Central Zone (high production area) were very significantly, older and more experienced than the other two production areas could be explained by the crazy passion of the producers in that area and also in view of the favorable climatic conditions for the production of cashew compared with other areas. Our results also show that the weakest areas allocated to cashew tree is mainly found in the low production area (North-east) despite the very significant extent of available land, suitable land with the highest number of agricultural manpower compared with other production areas. Our observations are similar to the results obtained by Agossou et al. (2012). According to these authors, most of the farmland in the Collines Department is occupied by cashew trees in association or not with annual crops. According to Balogoun et al. (2014), this situation could be explained by the fact that the production of cashew was adopted earlier in the Centre zone. This result also illustrates the importance given to other crops (especially cotton) by producers in the low production areas (notably North East) at the detriment of cashew tree which is much more considered in the Centre and northwest areas. One can also notice that the climatic conditions are not as favorable to development of the cashew tree in the low production areas as in the high production areas. Farmers are much more aware of the unfavorable climatic conditions for cashew production.

Indicators used by cashew producers to assess climate change

The study revealed that in general, the irregularity of rainfall, high temperature and violent winds are the main climate change indicators listed by cashew producers in their production areas in Benin. Same findings were reported by many authors (Mbow et al. (2009) in Senegal; Agossou et al. (2012) in Benin, Bambara et al. (2013) in Burkina Faso). According to Bambara et al. (2013), the cashew producers perception is explained by the fact that these three climate variables (rainfall, temperature and Wind) have a direct influence on agricultural production. These factors determine the best or bad agricultural season. It seems so memorable and visible to the producers compared with other climatic parameters such as Potential Evapotranspiration (PET), insolation, relative humidity, etc. Our indicators, compared with those obtained by Gnanglè et al. (2011), Agossou et al. (2012), Bambara et al. (2013) and Loko et al. (2013), revealed the new indicators like high rate of dried cashew flowers during the growing seasons and the constant declines in yields of cashew. The fact that increasing rates of dried flowers of cashew tree observed annually and yield declines are cited as indicators of climate change is not surprising. According to Ayanlade et al. (2010); Bambara et al. (2013), the following facts are the origin of these perceptions: (i) insufficient rainfall has resulted among other things, poor development of the cashew tree, (ii) increasing temperature causes the burning of crops and flowers of perennial species, creates a state of leaves plasmolysis unfavorable to crop development, (iii) increase in the frequency and intensity of winds cause, the falling of crops, the uprooting of trees, the drop of flowers, etc. Decreased productivity reported by producers in the high and average production areas as an indicator of climate change on the cashew tree was also shown on other crops such as yam (Loko et al., 2013), rice (Nwalieji and Uzuegbunam, 2012), and sorghum (MacCarthy and Vlek, 2012). The high number of indicators of climate changes related to rainfall and temperature compared with wind could be explained by the fact that rainfall and temperature are the most important climatic factors since they highly influence the productivity of cashew tree in the climatic conditions of Benin. Moreover, the cashew tree is very sensitive to temperature changes. Our results also showed that lack of rains, violent winds and high temperatures are the main factors identified by the producers; which affect the production of cashew. Similar famers perceptions were reported by many studies: Zimbabwe (Moyo et al., 2012); Zambia (Nyanga et al., 2011); Uganda (Kisauzi et al., 2012); Nigeria (Ugwoke et al., 2012); Ghana (MacCarthy and Vlek, 2012); South Benin (Yabi and Afouda, 2012) and Northwest of Benin (Loko et al., 2013) with yam producers. According to Ayanlade et al. (2010), this result was expected because the rainfall is the most important climatic factor affecting agricultural activities in the tropics. In addition, increase in the ambient temperature and the sunniness are favorable to certain crops, but it can lead to disastrous results on agriculture if it is associated with high rainfall deficit (Durand, 2007). From our observations, it appears that the indicators of climate change vary according to age and sex and the elder cashew producers (age ≥ 70 years) seem better perceived the irregularity of rainfall, high rates of dried flowers and the significant decrease in production as the climate change indicators while the adult cashew producers perceived the increase in the ambient temperature and wind speed. This result is similar to that made by Oyekale and Oladele, (2012) who reported that the ability to perceive climate change increase with age. However, according to the criterion of sex, we notice that, women, in their majority, perceived an increase in ambient temperature, high rates of dried flowers and a significant decline in production when compared to men. In rural African communities, men better perceive climate change, probably because of their regular contact with the external environment and their access to sources of information Oyekale and Oladele, (2012). However, the difference in perception between men and women was not significant in the context of this work.

Adaptation strategies for the cashew tree to climate change

Although most producers interviewed noted the negative effects of climate change on the cultivation of cashew, many of them (16.6%) did not develop any adaptation strategy, but prefered to confide to Divine clemency. This result is similar to that obtained by Nyanga et al. (2011) in Zambia; Tazeze et al., 2012) in Ethiopia, Luka and Yahaya, (2012) in Nigeria and Loko et al., 2013) in North West of Benin. According to Tidjani and Akponikpe, (2012), the various measures of adaptation are preventive and curative. Face with the threat of climate change on the survival of cashew producers, at local level the adaptation strategies are developed. The trends often vary by ethnic group, age, sex and socio-economic activities of households. Indeed, mulching, application of manures and regular maintenance of cashew plantations were the strategies developed or adopted by the most of cashew producers to mitigate the adverse effects of climate change. In India, Rupa et al. (2013) showed that several strategies can be used to reduce the vulnerability of the cashew trees to climate change. These include mulching or using plant or black bags in polyethylene, drip irrigation, the association of the cashew trees with green manure, fertigation and carbon sequestration. According to these authors, mulching, irrigation and green manure have beneficial effects on the humidity and temperature of the soil and on the growth and yield of cashew. Ended, climate change adaptation for agricultural cropping systems requires higher resilience against both excess of water (due to high intensity rainfall) and lack of water (due to extended drought periods). According to FAO (2007), a key element to respond to both problems is soil organic matter, which improves and stabilizes the soil structure so that the soils can absorb higher amounts of water without causing surface run off, which could result in soil erosion and, further downstream, in flooding. Soil organic matter also improves the water absorption capacity of the soil during extended drought. The non-adoption of irrigation as an adaptation strategy, especially in high productions areas (Centre) could be explained by the inability of farmers to carry out drilling which would have enabled them to facilitate irrigation. Indeed, in those areas, the presence of rocks, hills and granitic rocks in the soil did not facilitate the access to the water table. Irrigation would have been a strategy to recommend given the fact that it would be very difficult to adopt by producers. According to Mbow et al. (2009), farmers knowledge nowadays has become essential and is gradually gaining credit for their adaptability to the agro-ecological and social contexts and the accessibility for farmers with poor resources. Mulch with residues of plants or the application of manure is a renewable resource that can be incorporated into soil organic carbon (SOC). The use of mulches and other crop residues as adaptation strategies by farmers is not surprising. Indeed according to Dugue (2012), this strategy is used when rainfall is erratic or of greater intensity. Moreover, the more the spread mulch is thick, the more the residue left on the field, and the more the accumulation rate of SOC is high (Saïdou et al., 2012). Despite of all these methods and according to Baco et al. (2008), Akponikpè and Tidjani (2012), Dansi et al. (2013), the use of cultivars resistant to drought and water deficit seems to be an effective strategy to climate change. Unfortunately, cultivar resistant to climate change is yet to be identified since the introduction of cashew in Benin. Four main factors (Number of active men in household, experience of producers, the contribution of the cashew tree in household income and the interest to cashew) determine the choice of producers to adapt their cashew production to climate change in the study areas. Sex, age of the producer, education level, origin, marital status of the producer, the number of active women in the household, the area allocated to cashew and the source of funding of cashew production had no influence on the adoption of an adaptation strategy to the cashew plantation. These results are contrary to those obtained by Tazeze et al. (2012), in Ethiopia, Oyekale and Oladele (2012), in Nigeria and Loko et al. (2013), in Benin. However, these authors obtained the same results with regard to the experience of producers as determining the choice of any adaptation strategy. These results corroborate those obtained by Hassan and Nhemachena (2008) who showed that age and gender are not ineluctably factors determining the adaptive strategies developed at the local level, but rather the experience of farmers in agriculture and the capacity of households to have access to credit and market. According to Falola et al. (2012), the fact that cashew producers acquire and develop more skills over time allows them to take adaptive measures against the impact of climate change. However, the study conducted by Deressa et al. (2011) in Ethiopia, gave similar results and showed that the producers education level also increases the probability of climate change adaptation.

Conclusion

The manifestations of climate change and its negative impact on cashew were perceived by producers in the zones surveyed. Rainfall trends are felt through signs such as irregularity of rains and decline in rainfall. There was also increase in temperature and violent winds as indicators of climate change as well as high rate of dried cashew flowers every year leading low yield of cashew. The decline in rainfall, violent winds and high temperatures were the main factors identified by the cashew producers as affecting the productivity of cashew. Amongst the socio-cultural groups surveyed only the "Fon" ethnic groups were yet to use any adaptation strategy. The adaptation strategies used by the other ethnic groups included, mulching, the application of organic fertilizer and regular maintenance of plantations. We recommend assessing the efficacy of these adaptations strategies for sustainable cashew production in Benin.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

DOB , wrote the proposal questionnaire and conducted the surveys; LEA, AS, IPBA and NA are the one who validated the proposal and questionnaire, supervised the surveys and read the last draft of the paper; VAE, IB and DOB contributed to data statistical analysis and the writing of the first draft of the article.

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