

Research article

FARMERS' PERCEPTIONS OF USING BIOCHAR INTEGRATED WITH INORGANIC FERTILIZER FOR MITIGATING THE EFFECTS OF CLIMATE CHANGE ON CASHEW PLANTATIONS IN KOGI STATE, NIGERIA

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ABSTRACT

Cashew cultivation, which used to withstand the vagaries of weather, has become increasingly vulnerable to climate change, with losses of several seedlings within the first two years of field establishment. The study investigated the farmers' perceptions of the integrated use of biochar as a strategy to mitigate the adverse effects of climatic change on young cashew plants in Kogi State, Nigeria. Specifically, the study assessed farmers' awareness and willingness to adopt biochar technology for cashew plants and examined the effects of climate variability on cashew plants in Kogi State. Three Local Government Areas – Dekina, Olamaboro and Ofu – known for their prominence in cashew production were purposively selected. Farmers were selected from the list provided by the National Cashew Association of Nigeria (NCAN). Data were collected from 136 farmers through Focus Group Discussion (FGD) and interview schedule. Descriptive and inferential statistics were used for analyses. It was observed that the majority of the farmers (80.9%) had not been previously aware of biochar. However, a significant proportion of the farmers (96.3%) were willing to utilize the technology. This willingness was a result of the knowledge the farmers acquired during the FGD and their perceptions that biochar improves soil fertility for young cashew, conserves soil moisture during the dry season and provides an alternative strategy for managing organic soil waste. These factors were ranked first, second and third, respectively. It was also assessed that extension services ($\chi^2=11.973$, $p<0.05$) and membership in Cashew Farmers' Association ($\chi^2=19.098$, $p<0.05$) influence the farmers' perceptions of the integrated use of biochar to mitigate the effects of climate change. Therefore, the study recommends effective strategies for introducing biochar technology and other agronomic practices to cashew farmers by CRIN via group dynamics and advisory services.

Key words:

biochar, cashew, climate change, farmers' perception, Kogi State

Abbreviations:

ACA – African Cashew Alliance;
APPEALS – Agro Processing Productivity Enhancement and Livelihood Improvement Support; CRIN – Cocoa Research Institute of Nigeria; LGAs – Local Government Areas; FGD – Focus Group Discussion; NCAN – National Cashew Association of Nigeria; RCNs – Raw Cashew Nuts

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INTRODUCTION

Cashew is an exportable cash crop cultivated in tropical regions of South America, Africa and Asia. Cashew nuts, or kernels, are also important commodities in global trade. Previous studies highlighted great social and economic benefits accrued from cashew cultivation ([Sajeev and Saroj, 2015](#)). Although cashew is cultivated in various parts of the world, Africa has emerged as the world's leading producer of raw cashew nuts (RCNs), with West Africa being the primary production area. In 2018, the region harvested 1,795,000 metric tons of this product ([Ricau, 2019](#)). In Nigeria, cashew serves as an important source of revenue, supporting the livelihoods of millions of Nigerians involved in its cultivation and marketing. Commercial cashew cultivation in Nigeria dates back over six decades, while research into its cultivation, uses, processing, and economic importance began in early 1970s at the Cocoa Research Institute of Nigeria ([Adeigbe et al., 2015](#)).

In Nigeria, cashew farmers represent a substantial segment of the agricultural workforce, spreading across most of the 27 producing states and contributing over 95% of Nigeria's annual cashew product export ([Adeigbe et al., 2015](#)). According to [Oyekale et al. \(2009\)](#), a decline in cashew or fruit tree productivity in Nigeria can be linked to weather and climatic changes. It was found that increased evapotranspiration, together with an upsurge in the average temperature from November to February, is a factor impeding cashew productivity ([Oguntunde et al., 2014](#)).

Biochar is a relatively novel technology in Nigeria. It is produced through pyrolysis, which is a process of heating organic materials in the absence of oxygen ([Woolf et al., 2010](#)). During pyrolysis, labile biomass carbon converts into stable black carbon which can remain in the soil for a longer time. In this study, cashew crop residues were converted into biochar through a thermo-chemical process, facilitating handling and managing of biomass. Due to its high organic carbon content, application of biochar improves soil physiochemical characteristics, enhancing soil fertility while serving as a long-term carbon sequestration agent. Apart from its role in retaining the nutrient in the organic material in the soil for a longer time, cashew biochar also enhances water retention, particularly during rainy seasons, gradually releasing water during dry periods, thereby increasing soil water holding capacity and reducing nutrient leaching. Furthermore, biochar mitigates the effects of climate variability, thereby enhancing environmental sustainability and agricultural productivity. It also aids soil carbon storage and fertility leading to increased crop yields ([Cowie and Gaunt, 2009](#); [Smith et al., 2012](#)).

The global impact of climate change has been profound and terrifying: apart from the environmental devastation it has caused all over the world, climate change has had negative impact on societies through catastrophic effects of extreme climate conditions. In Africa and Asia, for example, frequent occurrences of floods, droughts, storms and oppressive heat are attributed to anomalies in weather conditions, mostly driven by human activities and actions. These anomalies have also resulted in a rise in greenhouse gases, hydrofluorocarbons as well as chlorofluorocarbons in the Earth's atmosphere, contributing to global warming. Climate change is widely regarded as the most severe environmental threat, not only because of its detrimental impact on agricultural productivity but also because it exacerbates the problems of hunger, malnutrition, disease and poverty in Africa ([Anselm and Taofeeq, 2010](#); [Agbongiarhuoyi et al., 2023](#)). Climate change remains one of the greatest challenges of 21st century, with far-reaching effects on the global economy. Climate scientists agree that climate change is real, while available evidence shows that its effects on our world are destructive and catastrophic.

Nigeria, with its teeming population, is particularly vulnerable to climate change, which has also negatively affected agriculture, food and livelihood ([Worldometer, 2023](#); [Dinar et al., 2006](#)). These impacts extend to food cultivation, farming and post-harvest activities. Agricultural systems in many African countries, including Nigeria, are largely weather-dependent, which makes them highly vulnerable to climate variability and change. A proper understanding of climate change is, therefore, essential for these countries to effectively respond to it and develop appropriate mechanisms and strategies to address its effects.

Cashew is a climate-sensitive crop, significantly affected by major variabilities in weather and climatic conditions, with adverse effects on its productive stages, including growth, yield, nut development and quality. The alarming intensification of climate change has led to an increase in pests, plant disease and water stress. Furthermore, extreme weather events, such as oppressive heat, super storms, torrential rains and floods, have negatively affected cashew productivity, leading to a decline in production across various agro-climatic zones. Climate change remains a major concern for farmers, particularly cashew farmer, due to adverse effects of bad weather on crop yields, especially cashew growth and development ([Adesiji et al., 2012](#); [Luka and Yahaya, 2012](#)). Certain adverse effects of climate change can be minimized or avoided through sound adaptation and mitigation strategies. The application of biochar, as one of the strategies of mitigating the effects of climate change, can improve productivity of cashew while also protecting the environment. Farmers, as the beneficiaries of this technology, had different perceptions and willingness to adopt biochar technology in their cashew farms. The main objective of this study was to investigate farmers' perceptions of using soil biochar in an integrated manner to reduce the impact of climatic variability and

change on young cashew establishments in Kogi State, Nigeria. The specific objectives were to examine the socio-economic characteristics of farmers, assess their awareness and willingness to adopt integrated biochar technology for young cashew establishments and investigate the effects of climate change on cashew plants in Kogi State.

MATERIAL AND METHODS

The study was carried out in Kogi State, Nigeria, which is bordered by Ekiti and Kwara states to the east and by the Federal Capital Territory to the north. Kogi State is the leading cashew producing state in Nigeria. It has 21 Local Government Areas (LGAs), three of which, Dekina, Olamaboro and Ofu, were purposively selected based on the prominence of cashew production. Farmers who participated in the study were selected from a list provided by the National Cashew Farmers' Association of Nigeria (NCAN). Using a systematic random sampling, 136 farmers were selected from the list, as follows: 55 from Dekina, 46 from Olamaboro and 35 from Ofu LGAs. The NCAN is an important association of cashew farmers not only in Kogi and but also in other cashew producing states in Nigeria. A Focus Group Discussion (FGD) was organized with the farmers. During the FGD, samples of biochar integrated with inorganic fertilizer were presented. The FGD was conducted before administering an interview schedule to assess the farmers' awareness and use of biochar (Figure 1). Key variables were measured at nominal levels, including education status, sex, marital status, access to extension services, membership in farmers' associations, willingness to use biochar and effects of climate change. The farmers' age and farming experience were measured at interval levels. Their perceptions of biochar application were assessed using yes/no responses, with scores assigned and mean scores calculated. The mean values were used to rank the responses accordingly. The data used was collected from the study area in June 2021.

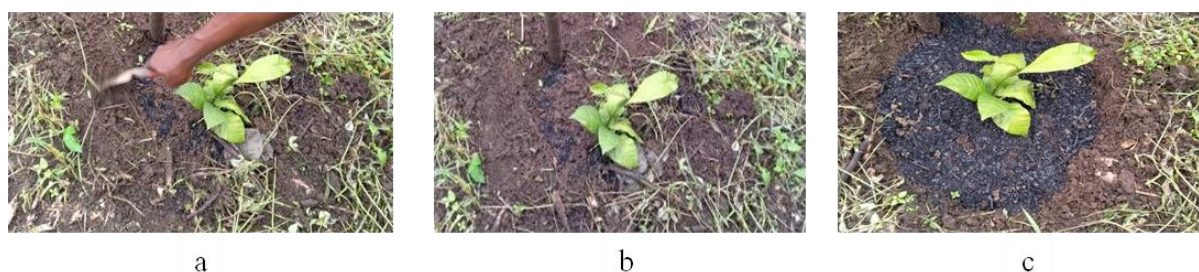


Figure 1. Biochar application on farm: a – young cashew plant; b – young cashew plant with a hole dug round it; c – application of biochar in a ring form around young cashew plant

Method of data analysis

The data collected through the interview schedule were analyzed using descriptive and inferential statistics. A chi-square test was employed to determine and establish the statistical link between the socio-economic variables of cashew farmers and their perceptions of using biochar integrated with inorganic fertilizer. The chi-square test was based on the formulation of a null hypothesis (H_0), which posits that two variables are independent (Bartlett et al., 2018). In this study, the null hypothesis was stated as follows:

H_0 : There is no significant relationship between the socioeconomic variables and farmers' perceptions of the integrated use of biochar for cashew plantations.

RESULTS AND DISCUSSION

Socio-economic characteristics of farmers

The variables in Table 1 reveal that 73.5% of the respondents were males, indicating the dominance of men in cashew production within the study area, while women comprised approximately one-third of the respondents. The majority of the respondents (91.2%) were married, a status usually associated with a sense of responsibility and engagement. In terms of educational status, 84.6% of the respondents had some form of formal education, ranging from primary to tertiary levels. Farmers with higher levels of education are more likely to embrace innovation to enhance their livelihoods, including adoption of cashew biochar technology. In terms of age distribution, 67% of the respondents were within the age range of 28-51 years, while 61.8% of the respondents had over 21 years of farming experience. This implies that the majority of the farmers were still in their productive years and active in cashew farming. It could be expected that these farmers were experienced in cashew production, which could help them in application of biochar to young cashew plants. Table 1 provides socio-economic characteristics of the farmers.

Table 1. Socio-economic characteristics of farmers (N=136)

Variables	Frequency	Percentage
Sex		
Male	100	73.5
Female	36	26.5
Marital status		
Married	124	91.2
Single	8	5.9
Divorced	2	1.5
Widowed	2	1.5
Educational status		
No formal education	21	15.4
Primary	24	17.7
Secondary	40	29.4
Tertiary	51	37.5
Age (years)		
20-27	15	11.0
28-35	25	18.4
36-43	44	32.4
44-51	22	16.2
52-59	14	10.3
60-67	9	6.6
68 and above	7	5.1
Farming experience (years)		
4-9	21	15.4
10-15	31	22.8
16-21	53	39.0
22-27	16	11.8
28-33	9	6.6
33 and above	6	4.4

Source: Authors' calculation

Economic characteristics of farmers

The majority of the respondents (60.3%) had farms ranging from 1 to 6 hectares, indicating relatively small-scale cashew farming in the study area. The small-scale farmers represent the major contributors in cashew production in Nigeria. Approximately 60% of the respondents earned less than half a million Naira (equivalent to 906.189 Euro) per annum from the sales of raw cashew nuts in the study area. For most farmers, this was the highest income category. In contrast, only 5.9% of the respondents had earnings above ₦1,374,003 (€3,624.764/year), which is a relatively small proportion. These figures indicate that cashew producers have limited earnings from the sales of raw cashew nuts, despite their commercial value. [Table 2](#) provides a summary of economic characteristics of the farmers.

Table 2. Economic characteristics of farmers (N=136)

Variables	Frequency	Percentage
Farm size (hectares)		
1-6	82	60.3
7-12	43	31.6
13-18	5	3.7
19-24	2	1.5
25 and above	4	2.9
Bags of cashew produced (80kg)		
2-7	32	23.5
8-13	24	17.7
14-19	14	10.3
20-25	15	11.1
26-31	26	19.1
32 and above	25	18.4

Amount generated (₦)	€ Equivalent/annum		
Less than 458,000	Less than 906.189	81	59.6
458,001 – 916,001	906.191 - 1,812.381	32	23.5
916,002 - 1,374,002	1,812.383 - 2,718.572	15	11.0
1,374,003 – 1,832,003	2,718.574 - 3,624.764	6	4.4
1,832,004 – 2,290,004	3,624.766 - 4,530.955	2	1.5
Exchange rate conversion for June 2021 was ₦505.413 to 1 Euro			

Source: Authors' calculation

Membership in farmers' associations

A significant proportion of the respondents (42.6%) were members of the Cashew Farmers' Association, as shown in Table 3. According to Kibue et al. (2018), involvement of cashew farmers in such organizations with access to extension services increases the likelihood of adopting practices such as biochar application. Participation of cashew farmers in group dynamics creates opportunities for learning and facilitates access to advisory services and other information supporting technology adoption, especially biochar utilization, which can mitigate the adverse effects of climate change.

Table 3. Membership in associations (N=136)

Variables	Frequency	Percentage
Membership in associations		
Cashew Farmers' Association	58	42.6
Cooperative Society	24	17.6
APPEALS	48	35.3
Village Meeting	6	4.4

Source: Authors' calculation

Awareness and willingness to use biochar integrated with inorganic fertilizer

The findings in Table 4 show the cashew farmers' awareness and willingness to adopt biochar integrated with inorganic fertilizer. The results reveal that a high percentage of the farmers (80.9%) had not been initially aware of biochar. However, a great majority (96.3%) expressed a willingness to utilize this technology as a result of participating in the Focus Group Discussion (FGD) with CRIN researchers and the farmers' perception that biochar improves soil fertility for young cashew plants. During the FGD, the farmers expressed interest in using this technology because the raw materials were readily available in their farms. They also reported that the integrated use of biochar was similar to fertilizer, improving soil fertility and enhancing cashew productivity during wet and dry seasons. These observations were corroborated by findings presented in Table 5. According to Ighalo and Adeniyi (2020), biochar was found to enhance soil properties, fertility and crop yields for cashew, radish, cocoyam, maize, sorghum and upland rice in Kwara, Ondo, Oyo, Ogun, Abia, Imo, Osun and Ebonyi States in Nigeria. In Kogi State, farmers showed high interest for adoption of biochar technology on their cashew farms, which could facilitate the adoption of the technology. Table 4 presents the farmers' responses regarding their awareness and willingness to use biochar integrated with inorganic fertilizer on cashew plants.

Table 4. Awareness and willingness to use biochar integrated with inorganic fertilizer for cashew (N=136)

Variables	Frequency	Percentage
Awareness of biochar		
Yes	26	19.1
No	110	80.9
Willingness to use biochar		
Willing	131	96.3
Not willing	5	3.7
Total	136	100.0

Source: Authors' calculation

Farmers' perceptions of using biochar integrated with inorganic fertilizer for cashew

Table 5 presents the farmers' perceptions of using soil biochar integrated with inorganic fertilizer on young cashew establishments. The study found that the perceptions of biochar as a means of improving soil fertility for young cashew and conserving soil moisture during the dry season ranked 1st and 2nd, respectively. The potential of biochar

as an alternative strategy for managing organic soil waste was ranked third. The findings align with those of [Nduka et al. \(2019\)](#), who reported positive outcomes of biochar application in cashew farming. Furthermore, they are in line with other studies indicating that cashew biochar facilitates water retention, especially during rainy seasons, and improves soil and crop productivity by enhancing soil nutrients and soil moisture ([Smith et al., 2012](#); [Scholz et al., 2014](#)). [Table 5](#) summarizes the findings on the farmers' perceptions of using biochar integrated with inorganic fertilizer for cashew cultivation.

Table 5. Farmers' perceptions of using biochar integrated with inorganic fertilizer for cashew (N=136)

Perceptions of biochar use for cashew	Mean	Standard deviation	Rank
Improves soil fertility	4.3407	0.89911	1
Conserves soil moisture	4.2794	0.97138	2
Alternative strategy	4.1838	0.96764	3
Promotes environmental sustainability	4.0515	1.07027	4
Improves soil health	4.0368	1.00670	5
Helps in nutrient retention	4.0299	1.19485	6
Helps to sequential carbon	3.9556	1.23908	7
Application can withstand climate change	3.8881	1.01611	8
Protects soil during dry season	3.8015	1.26283	9
Does not retain nutrient	3.7923	1.31595	10
Reduction of soil acidity	3.7895	1.08049	11
Does not enhance soil health for cashew	3.6593	1.35582	12
Cannot solve climate change problems	3.5076	1.26911	13

Source: Authors' calculation

Effects of climate change on cashew

The results in [Table 6](#) reveal that 88.2% of the farmers believed that cashew plants were affected by climate change. The primary ways that climate change affected cashew, as identified by the farmers, included: unpredictable rainfall (34.2%), reduction of water and nutrients (28.5), delays in the onset of rainfall (11.7%). Other variables were ranked lower, indicating that the first three factors were very important in cashew production, especially during the period of changing climate. These findings align with the study by [Bello et al. \(2017\)](#), which identified abnormal rainfall, increase in temperature and blustery weather as the major indicators of climate change.

Table 6. Climate change effects on cashew (N=136)

Climate change effects	Frequency	Percentage	Rank
Yes	120	88.2	-
No	16	11.8	-
Effects of climate change on cashew			
Unpredictable rainfall	41	34.2	1
Reduction of water and nutrients	31	25.8	2
Delays in the onset of rainfall	14	11.7	3
High temperature	12	10	4
Reduction in annual rainfall	11	9.2	5
Late termination of rain	5	4.2	6
Early termination of rain	3	2.5	7
Late onset of rain	2	1.6	8
Early onset of rain	1	0.8	9

Source: Authors' calculation

[Table 7](#) presents the Chi-Square (χ^2) analysis of the relationship between socio-economic characteristics of the cashew farmers and their perceptions of using biochar integrated with inorganic fertilizer. There was a positive and significant relationship between access to extension services ($\chi^2=11.973$, $p<0.05$) and membership in Cashew Farmers' Association ($\chi^2=19.098$, $p<0.05$) at 5% level of significance and the farmers' perceptions of using biochar integrated with inorganic fertilizers. These findings partially corroborate [Macarthy et al. \(2020\)](#), who stated that both farmers and extension officers require training on biochar use before disseminating the information to end-users. The results suggest that the farmers' perceptions of biochar use are positively influenced by access to extension services and membership in Cashew Farmers' Associations. Therefore, the null hypothesis (H_0) was rejected as there was a

significant relationship between the variables. The role of service providers, such as extension agents, in supporting cashew growers in farming communities and group affiliations foster the farmers' willingness to adopt biochar. Positive perceptions of biochar technology among farmers undoubtedly increase the likelihood of its adoption.

Table 7. Results of Chi-Square test showing the relationship between the socioeconomic variables of cashew farmers and their perceptions of using biochar integrated with inorganic fertilizer

Socio-economic variables	Df	χ^2	p value
Education	3	6.616	0.085
Sex	1	0.688	0.407
Marital status	3	7.065	0.070
Access to extension services	1	11.973*	0.001
Membership in farmers' associations	3	19.098*	0.000

Source: Authors' calculation

CONCLUSION

The study confirmed that cashew farmers were willing to apply biochar integrated with inorganic fertilizer to young cashew plants. This willingness was as a result of the knowledge gained during the Focus Group Discussion with CRIN researchers and the farmers' perception that biochar improves soil fertility of young cashew and conserves soil moisture during the dry season. Unpredictable rainfall and reduction of water and nutrients were perceived as the major effects of climate change on cashew cultivation. Most farmers were convinced that the integrated use of biochar could improve soil fertility, conserve soil moisture during the dry season and provide an alternative strategy for managing organic soil waste. Access to extension services and membership in Cashew Farmers' Association were key factors influencing the farmers' perceptions of biochar use as a means of mitigating the effects of climate change. The role of service providers, such as extension agents, and group affiliations foster the willingness of cashew growers to use biochar on their cashew farms. Based on the findings obtained in this study, it is recommended that the farmers' perceptions and the identified variables should be considered when developing programmes on using biochar as a climate change mitigation strategy in Nigeria. There should be practical mechanisms for introducing biochar technology integrated with inorganic fertilizers to cashew farmers by CRIN via group dynamics, demonstrations and advisory services. Additionally, actionable policies aimed at ensuring the adoption of biochar technology should be promoted by relevant authorities in order to adapt and sustain cashew production in the face of a changing climate. Based on the foregoing recommendations, further research should center on capacity building for farmers on biochar preparation and application to cashew plantations. Furthermore, studies examining the adoption of this technology are recommended.

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