



Assessing the Utilization of Agricultural Biotechnology by Farmers for Sustainable National Development in Cross River State, Nigeria

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ABSTRACT

This study investigated the utilization of agricultural biotechnology by farmers in Cross River State, Nigeria, with a focus on its contribution to sustainable national development. Despite growing awareness of biotechnology in Nigerian agriculture, adoption among rural farmers remains limited. The study employed a descriptive survey research design. A structured questionnaire was administered to a sample of 600 farmers selected through multi-stage sampling across the three senatorial districts of the state. Data were analyzed using descriptive and inferential statistics. Findings revealed that although a significant number of farmers are aware of biotechnology, only a small proportion actively utilize it in their farming practices. Key barriers to adoption include poor extension services, misinformation, high costs of biotech inputs, and inadequate institutional support. However, where adopted, biotechnology has led to increased productivity, higher income and improved environmental sustainability. The study concludes that enhancing biotechnology adoption requires targeted education, improved extension services and policy reforms that ensure affordability and accessibility. It recommends strategic interventions involving government, research institutions, NGOs, and media to facilitate the integration of biotechnology into mainstream agricultural practices for sustainable development.

Keywords: Agricultural Biotechnology, Farmers, Utilization, Sustainable Development, Cross River State, Nigeria.

INTRODUCTION

In the face of growing concerns over food insecurity, environmental degradation, and the limitations of traditional agricultural practices, agricultural biotechnology has emerged as a viable tool for enhancing food production and fostering sustainable development. Globally, the use of biotechnology in agriculture has led to the development of crops with increased yield, pest and disease resistance, improved tolerance to abiotic stress, and enhanced nutritional quality. According to Adebayo and Abubakar (2022), biotechnology has revolutionized modern agriculture by making it possible to respond more effectively to the challenges posed by climate change and soil degradation. Yet, despite these prospects, the actual utilization of agricultural biotechnology in developing countries like Nigeria remains relatively low and uneven, particularly at the grassroots level.

Nigeria, a country with immense agricultural potential, is yet to fully harness the benefits of biotechnology for sustainable development. With over 70% of its rural population dependent on subsistence farming, the adoption of agricultural biotechnology could serve as a catalyst for improved agricultural productivity, income generation, and national economic growth (Okonkwo & Udeh, 2021). The need to improve the agricultural sector in Nigeria is further amplified by the persistent issues of low yield, post-harvest losses, food import dependence, and a growing population. Balogun and Osagie (2020) observe that while policy documents often emphasize modernizing agriculture through innovation, implementation is often undermined by infrastructural decay, inadequate funding, and limited farmer education.

Biotechnology offers the potential to transform Nigerian agriculture by introducing genetically modified crops that can thrive under challenging environmental conditions and produce higher

yields with fewer inputs. Ezeanya and Ifeanyi (2023) argue that the adoption of such technologies is not merely a scientific imperative but a developmental necessity in Nigeria, where food insecurity remains a recurring crisis. Despite government efforts, including the National Biotechnology Development Agency (NABDA), the National Biosafety Management Agency (NBMA), and the passage of biosafety legislation, there is still a wide knowledge gap and low adoption rate of biotechnology innovations among farmers in many rural areas.

Cross River State, with its diverse agro-ecological zones and a high percentage of the population engaged in farming, offers a compelling case for examining the utilization of biotechnology. The state is known for its production of crops like cassava, yam, maize, rice, and cocoa—many of which have genetically modified variants that could significantly improve yields. However, Nnamani and Iroegbu (2024) report that limited access to biotechnology tools, low farmer literacy levels, and lack of effective extension services have restricted the diffusion of such innovations in the region. Essien and Ekanem (2023) add that although Cross River State has the potential to serve as a model for agricultural transformation, underutilization of scientific innovations continues to stifle progress.

Furthermore, the lack of proper orientation and misinformation about genetically modified organisms (GMOs) have compounded the challenges of adoption. Tunde and Ibrahim (2022) found that many farmers harbor fears about the safety of biotech crops, often confusing scientific facts with rumors and myths. This is exacerbated by insufficient stakeholder engagement, where farmers are not adequately involved in decision-making processes regarding agricultural biotechnology policies. Bello and Musa (2023) assert that until there is a deliberate attempt to demystify biotechnology and build farmers' confidence in its safety and utility, the rate of adoption will remain discouraging.

In addition to information gaps, structural and institutional factors play significant roles in determining the extent of biotechnology utilization. Access to quality seeds, supportive agricultural policies, infrastructure such as roads and storage facilities, and access to markets all influence farmers' willingness to embrace biotechnology (Yusuf & Aliyu, 2022; Umeh & Ogbonna, 2023; Chima & Okorie, 2024; Agbaje & Salami, 2021). Unfortunately, in many rural areas of Cross River State, these enabling conditions are absent or insufficient. Ibrahim and Gambo (2022) suggest that biotechnology adoption is not only a matter of technological availability but also of socio-economic and institutional readiness.

Moreover, agricultural extension services, which serve as the main conduit for delivering new agricultural technologies to farmers, are underfunded and understaffed in most parts of Nigeria. According to Okafor and Nwachukwu (2020), the disconnect between research institutions and end-users (farmers) is a critical barrier to technology transfer. Extension officers are often not trained in biotechnology themselves and, therefore, lack the capacity to effectively communicate its benefits and application. This institutional shortfall has created a vacuum, allowing misinformation and fear to thrive among farmers, thereby weakening the prospects for wide-scale adoption.

Despite these challenges, there are success stories where farmers who accessed and utilized biotechnology reported increased productivity, reduced production costs, and greater resilience to environmental stress (Eze & Anyaehie, 2021; Olatunde & Ibeh, 2023). These successes point to the potential of biotechnology to contribute meaningfully to the attainment of the Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger), SDG 12 (Sustainable Consumption and Production), and SDG 13 (Climate Action). If well implemented, biotechnology can increase agricultural efficiency, conserve biodiversity, and promote rural development. Therefore, assessing the extent to which farmers in Cross River State utilize agricultural biotechnology is both timely and necessary for improving agricultural policies, designing targeted extension programmes, and formulating educational campaigns that enhance farmer engagement with biotechnology through science-driven farming practices.

Several empirical studies have examined the extent to which farmers adopt agricultural biotechnology in pursuit of sustainable development outcomes. Adebayo and Abubakar (2022) conducted a survey among 300 farmers in Kaduna and Kano States using structured questionnaires and interviews. The study revealed that while awareness of biotechnology was relatively high

(65%), actual utilization remained low (28%) due to fear of genetically modified organisms (GMOs), inadequate training, and poor access to biotech inputs. They concluded that a lack of targeted extension services and misinformation were the major inhibitors to biotechnology adoption in rural areas.

Similarly, Ezeanya and Ifeanyi (2023) investigated biotechnology usage among cassava farmers in Imo State using a mixed-methods approach involving focus group discussions and field observations. Their findings showed that although some farmers were willing to use disease-resistant cassava varieties developed through biotechnology, most lacked the technical knowledge for implementation. The study identified the absence of training programs and inadequate seed supply systems as critical factors limiting the effective adoption of biotechnology for enhanced food security and income generation.

Balogun and Osagie (2020) explored the impact of agricultural biotechnology adoption on farmers' productivity in Ogun State through a quasi-experimental design. The results indicated that farmers who adopted genetically improved maize and cowpea varieties recorded a 35% increase in yield and reduced post-harvest losses by 20% compared to those using traditional seeds. However, only 19% of farmers in the sample had access to such technologies, mainly due to weak linkages between research institutions and local communities.

In a broader study covering six states in Nigeria, Yusuf and Aliyu (2022) surveyed 450 smallholder farmers and employed logistic regression to assess the predictors of biotechnology adoption. They found that education level, access to extension agents, farm size, and proximity to urban centers were statistically significant determinants. The study stressed that socio-economic factors play a key role in technology adoption and called for an inclusive policy framework to support rural farmers, particularly women and youth.

Essien and Ekanem (2023) carried out a comparative analysis between adopters and non-adopters of biotechnology in Cross River and Akwa Ibom States. Using descriptive statistics and chi-square tests, they discovered that adopters reported improved resilience to pests and climate variability, contributing to food security and environmental sustainability. However, the study also noted that extension services in the region were grossly underfunded, limiting farmers' exposure to available biotechnological innovations.

Chima and Okorie (2024) examined biotechnology's contribution to sustainable agriculture using data from 200 farmers in Ebonyi State. Their research utilized both quantitative and qualitative tools to assess perceptions and outcomes. Findings showed that biotechnology adoption led to reduced chemical usage, better soil conservation practices, and increased income among users. Nonetheless, cultural resistance and lack of institutional support remained major setbacks. The authors concluded that unless deliberate government interventions are put in place, the national development agenda through biotechnology will remain aspirational. Obinna and Uwakwe (2022) studied the role of non-governmental organizations (NGOs) in promoting biotechnology awareness among farmers in Enugu State. Their study showed that NGO-led trainings improved adoption rates by 40% among targeted communities. They emphasized the importance of multi-sectoral partnerships in enhancing sustainable development outcomes. Likewise, Ibrahim and Gambo (2022), in their study on agricultural biotechnology and rural development in Bauchi State, found that biotechnology contributed to increased household food availability and income diversification, although challenges like infrastructural deficits and input costs persisted.

In another study by Tunde and Ibrahim (2022), the authors assessed biotechnology adoption in semi-arid areas of Northern Nigeria. Using structural equation modeling, they found that farmers perceived biotechnology as a solution to drought-related crop failure and erratic rainfall patterns. Adoption was positively associated with perceived economic benefits, though limited by religious and ethical concerns. Similarly, Agbaje and Salami (2021), in a study conducted in Oyo State, found that despite high levels of awareness, adoption remained under 30% due to distrust in government policies and poor extension delivery. Also, Umeh and Ogbonna (2023) investigated the influence of media and ICT tools in biotechnology adoption across five LGAs in Delta State. Their study showed

that farmers exposed to biotechnology information via radio, mobile apps, and agricultural TV programmes were significantly more likely to adopt new biotech practices. The authors concluded that sustainable development through biotechnology requires not only scientific advancement but also deliberate information dissemination strategies.

The reviewed studies reveal that while awareness of agricultural biotechnology among Nigerian farmers is on the rise, actual adoption rates remain significantly low (Adebayo & Abubakar, 2022; Agbaje & Salami, 2021). Key obstacles hindering widespread utilization include weak extension services, widespread misinformation, and a lack of institutional and policy support (Ezeanya & Ifeanyi, 2023; Essien & Ekanem, 2023). However, the literature consistently shows that adoption is positively associated with farmers' level of education, access to ICT tools, involvement of non-governmental organizations, and perceived economic benefits (Yusuf & Aliyu, 2022; Umeh & Ogbonna, 2023). Where biotechnology has been adopted, evidence points to increased agricultural productivity, improved income levels, and enhanced environmental sustainability (Balogun & Osagie, 2020; Chima & Okorie, 2024). Despite these findings, there is a noticeable gap in region-specific empirical data—particularly in Cross River State—regarding how local farmers utilize biotechnology tools, what contextual barriers they face, and the strategies necessary for scaling up adoption. This present study aims to fill this gap by providing localized, data-driven insights that can inform tailored interventions for sustainable national development.

MATERIALS AND METHODS

The study was conducted in Cross River State, located in the South-South geopolitical zone of Nigeria. The state is characterized by a tropical climate with two distinct seasons—wet and dry—and is known for its rich biodiversity and fertile agricultural land. Major crops cultivated include cassava, maize, yam, plantain, and rice. The state is divided into three agricultural zones: Ogoja, Ikom, and Calabar, each comprising several local government areas where farming is the primary occupation of the rural population. The study adopted a descriptive survey research design to assess the extent of utilization of agricultural biotechnology among farmers. This design enabled the collection of data from a cross-section of respondents to describe prevailing conditions regarding biotechnology awareness, access, and adoption for sustainable development. The population consisted of all registered and practicing farmers across the three agricultural zones of Cross River State. These included both smallholder and medium-scale farmers engaged in crop and livestock production. According to the Cross River State Ministry of Agriculture (2024), the estimated population of registered farmers is approximately 25,000.

A total sample size of 600 farmers was selected using a multi-stage sampling technique. First, two local government areas were randomly selected from each of the three agricultural zones, making a total of six LGAs. Secondly, from each LGA, 100 farmers were selected through stratified random sampling, ensuring representation across gender, age, and type of farming enterprise. The main instrument used for data collection was a structured questionnaire titled: Agricultural Biotechnology Utilization Questionnaire (ABUQ). The questionnaire was divided into five sections, capturing demographic characteristics, awareness, access, adoption, and perceived benefits and constraints of biotechnology. The instrument was validated by experts in agricultural extension and rural sociology, and a pilot test was conducted among 30 farmers in Akwa Ibom State, yielding a Cronbach's alpha reliability coefficient of 0.82. Data were collected with the help of trained research assistants who are fluent in both English and local languages. The questionnaires were administered face-to-face to ensure accurate responses, especially among less literate farmers. Ethical clearance was obtained, and verbal informed consent was secured from all respondents. Quantitative data were analyzed using descriptive statistics (frequency counts, percentages, and mean scores) and inferential statistics such as Chi-square tests and logistic regression analysis to determine the relationship between demographic variables and biotechnology adoption. Data were analyzed using SPSS version 25. Results were presented in tables and interpreted accordingly.

RESULTS

1. Demographic Characteristics of Respondents

The study involved 600 farmers drawn from the three agricultural zones of Cross River State. Analysis of demographic data showed that 65% of the respondents were male, while 35% were

female. The age distribution indicated that 54% of the farmers were between 36 and 55 years old, suggesting that the majority were in their economically active years. Most respondents (62%) had at least secondary education, and 72% were engaged in full-time farming. This demographic profile reflects a predominantly literate farming population capable of understanding and potentially applying biotechnological innovations.

2. Awareness of Agricultural Biotechnology

Results revealed that 68% of the respondents had heard of agricultural biotechnology, primarily through radio, extension agents, and farmers' cooperatives. However, only 40% demonstrated a clear understanding of what biotechnology entails. Awareness was highest in Calabar agricultural zone and lowest in Ogoja zone. This finding suggests a growing awareness gap that may hinder informed decision-making regarding the adoption of biotechnology practices.

3. Access to Biotechnology Resources

Only 29% of respondents reported having access to biotechnology-related inputs or resources (e.g., improved seeds, tissue culture plants, or bio-fertilizers). Limited access was attributed to inadequate extension services, high cost of biotech inputs, and poor distribution networks. Most farmers relied on conventional methods of farming and were unaware of how to access biotechnology support systems, indicating a critical infrastructural and institutional weakness.

4. Adoption of Agricultural Biotechnology Practices

Just 22% of the respondents confirmed they had adopted at least one form of agricultural biotechnology. Practices included the use of improved genetically modified seeds, bio-pesticides, and composting techniques. Adoption was more common among younger, more educated farmers who were members of cooperative societies or had previous training from NGOs. Statistical analysis showed a significant positive correlation ($p < 0.05$) between education level, access to information and technology adoption.

5. Perceived Benefits and Challenges

Among those who adopted biotechnology, 87% reported increased yields, 75% experienced reduced input costs, and 63% indicated that their farming practices became more environmentally sustainable. However, key challenges identified by the broader respondent group included lack of training (78%), misinformation and fear of genetically modified organisms (66%), and poor government support (59%). Farmers also expressed concern over the affordability and long-term effects of biotechnology products.

6. Role of Institutional and Policy Support

Only 18% of respondents acknowledged receiving any support from government agencies, and a mere 10% had ever participated in a biotechnology training session. Farmers emphasized the need for targeted government policies, subsidies, and better coordination between research institutions and extension agencies. The regression analysis revealed that policy awareness significantly influenced biotechnology adoption ($\beta = 0.54$, $p < 0.01$).

DISCUSSION

The findings of this study provide valuable insights into the utilization of agricultural biotechnology by farmers in Cross River State and its implications for sustainable national development. The demographic data indicate a relatively literate and active farming population, which theoretically should facilitate the adoption of modern farming technologies. However, the gap between awareness and actual adoption underscores significant challenges in the diffusion of biotechnology.

Awareness of agricultural biotechnology is increasing, but comprehension remains limited. Many farmers have heard about biotechnology but lack detailed knowledge of its application, benefits, and safety. This aligns with earlier studies by Adebayo and Abubakar (2022) and Agbaje and Salami (2021), which reported similar trends across other parts of Nigeria. Limited access to biotechnology inputs and services, as reported by a majority of the respondents, also mirrors findings from Ezeanya and Ifeanyi (2023), who noted poor institutional frameworks as a hindrance to adoption.

Adoption is significantly influenced by education, ICT exposure, and NGO involvement—factors that were positively correlated with biotechnology use. This supports the work of Yusuf and Aliyu (2022), who argued that informed farmers are more likely to take calculated risks associated with innovation. Despite the relatively low adoption rate, those who adopted biotechnology reported increased yields, reduced costs, and enhanced environmental sustainability, confirming earlier findings by Balogun and Osagie (2020) and Chima and Okorie (2024).

Nonetheless, widespread challenges such as misinformation, high costs, limited training, and weak institutional support are consistent across the literature and were strongly emphasized by farmers in this study. The persistent lack of government-led interventions and extension support remains a recurring barrier, calling for urgent policy attention.

CONCLUSION

This study concludes that while the level of awareness of agricultural biotechnology among farmers in Cross River State is moderately high, actual utilization remains significantly low due to infrastructural, institutional, and knowledge-related barriers. Farmers who utilize biotechnology report meaningful benefits, indicating its potential in driving agricultural productivity, income generation, and environmental sustainability. However, the disconnect between policy intentions and field-level realities continues to impede the broader impact of biotechnology on national development.

RECOMMENDATIONS

Based on the findings of this study, the followings are recommended thus:

1. Government agencies and NGOs should collaborate to design and implement intensive awareness and training programs on biotechnology, particularly targeted at rural farmers.
2. Strengthening the capacity of agricultural extension officers and improving coordination between research institutions and the Ministry of Agriculture is crucial to ensure biotechnology inputs and information reach end-users.
3. Subsidies and financial incentives should be provided for certified biotech inputs such as improved seeds and bio-fertilizers to encourage widespread adoption.
4. Use of ICT tools, radio, mobile apps, and community sensitization through cooperative societies should be expanded to bridge the information gap.
5. Policymakers should review and update agricultural biotechnology policies to enhance their responsiveness to farmers' contextual needs, and ensure that these policies are widely communicated and implemented.
6. Encourage local universities and agricultural research institutions to tailor biotechnology innovations to the specific ecological and socio-economic context of Cross River State.

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