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Impact Evaluation of the Use of PBR Cowpea in Nigeria

Baseline Report

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Acronyms

AATF	African Agricultural Technology Foundation
ADP	Agricultural Development Project
Bt	*Bacillus thuringiensis*
CAPI	Computer-assisted personal interview
GM	Genetically modified
HH	Household
IE	Impact evaluation
IFPRI	International Food Policy Research Institute
LGAs	Local government areas
PBR	Pod-borer resistant
RCT	Randomized controlled trial
SD	Standard deviation
USAID	United States Agency for International Development

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1. Introduction

Nigeria is the largest consumer and producer of cowpea[3] in Africa. Produced predominantly by smallholder farmers, cowpea is relied on by millions of Nigerians and is one of their main sources of affordable protein. Despite cowpea's economic relevance (Nwagboso et al. 2024; Phillip et al. 2019), cowpea yields in Nigeria have barely grown over the last 20 years. One of the main abiotic constraints of the crop is the pod-borer insect (*Maruca vitrata*), which can cause damages of up to 80 percent. Given that conventional breeding has not been successful in addressing this constraint, local and international efforts over the last decades focused on developing a pod-borer-resistant (PBR) cowpea. The culmination of these efforts in Nigeria was the commercial release of the PBR cowpea variety SAMPEA-20T in late 2019. This is a significant milestone, as it was the first transgenic food crop to be approved for cultivation in Nigeria. In its programming under the "Feed the Future Innovative Maize and Cowpea Technologies to Increase Food and Nutrition Security in Africa" activity, implemented by the African Agricultural Technology Foundation (AATF), the United States Agency for International Development (USAID) aims for an adoption rate of PBR cowpea in Nigeria of 25 percent by 2025, with yield gains of 20 percent and accompanying reductions in pesticide applications.

The International Food Policy Research Institute's (IFPRI) Program for Biosafety Systems (PBS) is leading a five-year (2021–2026) impact evaluation (IE) project, funded by USAID. The study goal is to generate causal evidence of the use of the PBR cowpea variety and its consequential household and farm impacts and associated value chain effects. In a collaboration with IFPRI's Nigeria Country Office, PBS is leading and coordinating the overall study while the IFPRI-Nigeria Country Office designs and implements the quantitative and qualitative approaches to the evaluation. IFPRI has worked with technology developers, the AATF and its partners (including private local seed companies), to ensure access to necessary data and cooperation by the evaluation team, while maintaining the team's independence. To ensure such required independence, the evaluation team has separated the cooperation in implementing the evaluation (including distributing inputs) from the data analysis. The evaluation team will continue to maintain its independence in the methodological approach and the analysis of the results from the implemented randomized controlled trial (RCT), adhering to international standards.

To assess the impact of PBR cowpea, IFPRI is implementing a cluster RCT to assess the impact of using PBR cowpea and to evaluate key outcomes related to changes in cowpea yields, productivity, and pesticide applications (Andam et al. 2023). The IE will use mean differences and regression

[3] In Nigeria, as well as in many other West African countries, cowpeas are known as "beans." The name cowpea is widely used in the literature but is not commonly recognized or used by the public. Its origin appears to be that it was widely used as fodder for cattle in the United States. The first use of this word dates to 1776 (Merriam-Webster.com Dictionary, Merriam-Webster, www.merriam-webster.com/dictionary/cowpea. Accessed March 7, 2024).

analysis, based on survey data, to determine causal impacts of the use of PBR cowpea and complementary inputs. Other outcomes evaluated include changes in farm labor, production costs, gross and net farm revenues, shares of cowpea harvest sold, food availability and nutrition, and health outcomes from expected reductions in pesticide applications. Results of this IE are expected to be of interest to a range of diverse stakeholders and audiences in Nigeria, in the region, and globally.

The evaluation team is implementing the RCT with randomly selected communities in Adamawa and Kwara. There are two treatment groups: the first one (T1) has received PBR cowpea plus fertilizer and pesticide for 2 kg of PBR cowpea package; the second (T2) received the 2 kg of PBR cowpea package exclusively. The control group has received conventional cowpea seed packages. As with other IEs, the evaluation team encountered a number of implementation challenges in the field. These included the prevailing insecurity across rural Nigeria, difficult terrains and a poor road network, reluctance to participate by some community members who were listed but not selected as part of the sample and demands for immediate benefits and incentives for participating in the survey.

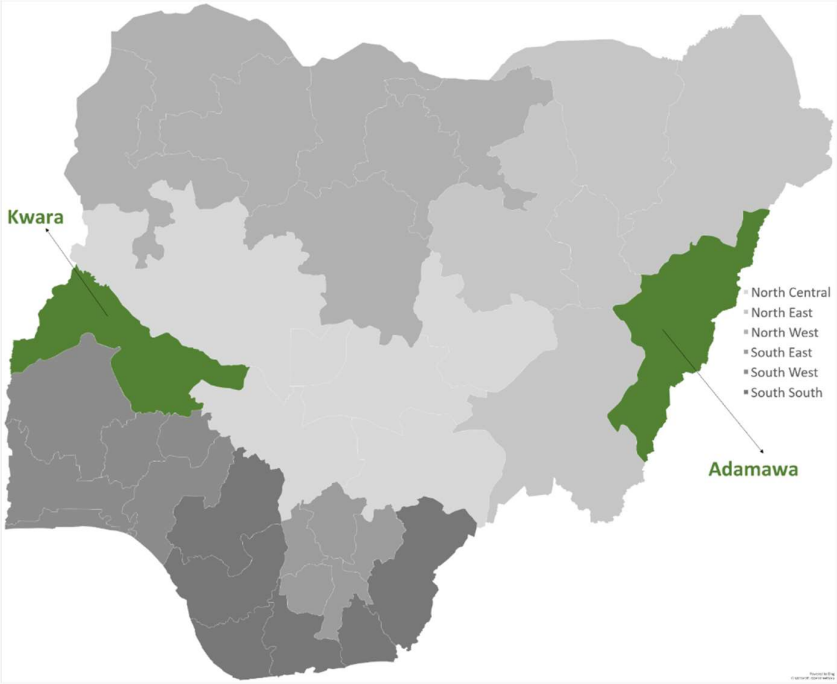
This report summarizes the main descriptive findings of the IE baseline survey implemented in the study locations of Adamawa and Kwara, which uncovered insights into cowpea production practices, household characteristics, health outcomes, and food security status of participating household and farmers. The report serves several purposes, in addition to providing an overview of cowpea production and household characteristics, health status, and food security status of the cowpea-producing households participating in the IE. First, the report describes the prevailing conditions, challenges, and opportunities within the cowpea value chain and its possible implications for the final IE results. Second, the report shows that there is a balance in household characteristics between the treatment and control groups of the IE, thus ensuring that the final results can be attributed to the RCT intervention and not to other competing explanations. Third, in terms of external validity of the IE, the report reveals significant differences between Adamawa and Kwara in cowpea agricultural practices, household characteristics, food security, and market dynamics. The differences point to the usefulness of selecting two dissimilar states for this analysis, thus ensuring that the final IE results will represent varying features of northern Nigeria. In this way, the descriptive analysis presented in this report has helped inform the IE implementation and the design of the next survey round.

The rest of the report is structured as follows. Section two describes the study sites and sampling approach. Section three describes the survey implementation, and section four provides a detailed description of the households in the two states across various relevant characteristics. Sections five through nine describe the pesticide applications, production, marketing, household health, and food security status. The last section summarizes the main findings and offers some general conclusions.

2. Study Sites and Sampling Approach

Adamawa and Kwara states were selected for the IE study (Figure 1). Both states are among the leading cowpea-producing areas in Nigeria. The security situation in major cowpea-producing states was considered in this selection process. In addition, the relatively high share of female-headed households engaged in cowpea production was part of the selection criteria. No bias was introduced by targeting states with a high proportion of females, because it is expected that the random selection will even out any differences between treatment and control groups.

Figure 1 Map of Nigeria with study sites



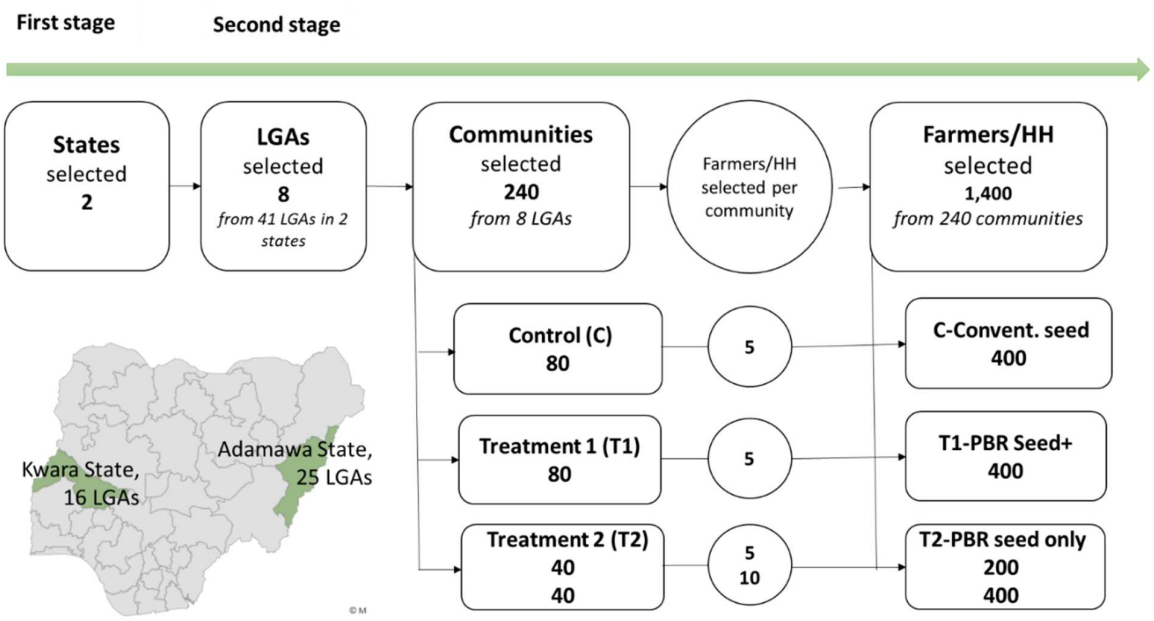
Source: Authors' elaboration.

The four selected local government areas (LGAs) in each state are similar in relevant contextual factors such as size, socioeconomic and agroclimatic conditions, and road and market access. Using the community lists provided by the Agricultural Development Project (ADP), the research team randomly selected 240 communities from the 8 LGAs that had high concentrations of cowpea farmers.

The selection of states, LGAs, communities, and households included in the household survey followed a multistage sampling procedure. In the first stage, the team purposely selected Adamawa and Kwara. In the second sampling stage, four LGAs were selected in each state from 25 total LGAs of Adamawa and 16 total LGAs of Kwara. From the 8 LGAs, 240 communities were selected that had similar contextual factors, with 80 communities comprising the control group and the remaining 160 communities comprising the treatment groups. Within each community, all households were

listed, from which five cowpea farmers were randomly selected to participate in the study for the baseline and endline surveys. Figure 2 illustrates this multistage sampling procedure.

Figure 2 Multistage sampling procedure



Source: Authors' elaboration.

Note: LGAs = local government areas; HH = household; C-Convent. = control-conventional; PBR = pod- borer resistant.

The power calculation indicated that approximately 1,200 households were required to detect an effect. Sample sizes were estimated at 400 farm households per treatment group (T1 and T2), and another 400 farm households for the control group. To account for the attrition rate, the sample size was increased by 200 households. Given that adding 200 households to either group has no effect because all communities (treatment and control groups) were selected randomly, 200 households were added to the T2 group in our sample, as shown in Figure 2. Table 1 lists the eight selected LGAs along with the number of treatment and control households selected.

Table 1 Selected local government areas

State	LGA	Treatment 1	Treatment 2	Control	Total
Kwara	Edu	75	50	50	175
	Pategi	75	50	50	175
	Ifelodun	74	50	50	174
Adamawa	Kaiama	75	50	50	175
	Maiha	75	50	50	175
	Mubi South	75	50	50	175
	Hong	75	50	50	175
	Song	75	50	50	175
Total		**599**	**400**	**400**	**1,399**

Source: Authors' elaboration.

The IE strategy is a cluster randomized design in which treatment and control units (farmers) are clustered by community. One of the critical considerations of this kind of design is to ensure a balance between clusters (communities) in both treatment and control arms regarding baseline characteristics that could influence the outcome of interest, leading to biased estimates. Table 2 summarizes these characteristics.

Table 2 Mean values of baseline characteristics, by treatments and control group

Characteristic	Adamawa			Kwara			Total		
	T	C	Diff.	T	C	Diff.	T	C	Diff.
Age of household (HH) head	44.16	43.55	0.61	43.55	44.67	-1.12	43.86	44.11	-0.26
HH size	5.77	5.86	-0.09	5.97	5.94	0.03	5.87	5.90	-0.03
Plot size (ha)	1.83	2.23	-0.40**	4.27	3.29	0.98**	3.01	2.74	0.27
Pesticide used (lt)	3.69	3.42	0.27	11.60	10.89	0.71	7.67	7.23	0.45
Quantity of pesticide per (lt)	3.90	2.84	1.05*	6.61	5.93	0.68	5.26	4.41	0.84
Total cost of pesticides (1,000 naira)	11.37	11.26	0.11	60.45	55.42	5.03	36.10	33.75	2.35
Cost of herbicides (naira)	24.47	23.89	0.58	50.23	49.95	0.28	37.53	36.10	1.44
Quantity discarded because of pest/disease (kg)	38.28	56.24	-17.96*	95.31	103.47	-8.16	112.66	85.49	27.17
Cowpea yield (kg/ha)	301.07	240.86	60.21	445.11	479.40	-34.39	384.62	380.61	4.01
Value of sale of cowpea (1,000 naira)	85.35	92.61	-7.26	622.71	643.00	-20.29	416.54	436.26	-19,72

Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey (2023).
Note: ** significant at the 1% level; * significant at the 5% level. T = treatment group (1 and 2); C = control group; Diff. = difference.

Table 2 reflects this balance across treatment and control groups at the community level, suggesting that randomization was generally successful. However, there are significant differences in a few variables, such as plot size and quantity discarded because of pests and diseases in Adamawa. This indicates that while randomization helps to ensure that groups are comparable, it doesn't always guarantee a perfect balance in every possible confounding factor. These differences will be accounted for in the impact estimation strategy to derive valid and reliable conclusions about the treatment's effect on the outcomes of interest (Ahmed et al., 2019; Amare and Asfaw, 2012).

3. Survey Implementation

The baseline household survey was implemented by a Nigeria-based consulting firm with expertise in conducting household surveys. Extension agents of the state ADPs in both Adamawa and Kwara provided a comprehensive list of all 13,999 households that planted cowpea. IFPRI prepared a draft baseline survey questionnaire, which was peer-reviewed and revised to address comments and suggestions. The questionnaire was also pretested with cowpea farmers. Thirty-one enumerators and eight supervisors were trained. Field supervisors received additional training on security, confidentiality issues, and their supervisory roles, which included assigning enumerators to selected households, reporting field updates, tracking household revisits, and conducting other tasks to ensure smooth implementation of the fieldwork.

The pilot survey was carried out in two communities on the fourth day of training among cowpea farmers to ensure enumerators' survey comprehension. The two rounds of field testing were critical to identify and resolve comprehension and flow of the questionnaires. The local survey agency programmed the questionnaire for computer-assisted personal interview (CAPI) – Survey CTO.

Prior to survey administration, the team received the required authorization to implement the survey from the National Health Research Ethics Committee of Nigeria, Department of Health Planning, Research and Statistics, and Federal Ministry of Health. To ensure quality of the household survey data, the team used CAPI to reduce the possibility of human error during data entry with the help of skip pattern and other programmed responses; the team also used text audit to provide detailed information on how enumerators moved through the questionnaire, how much time was spent on each question, and what path they followed. All datasets created were stripped of information (names, phone numbers, and addresses) that would allow the identification of an individual or household. A separate dataset linking identifiers with the information allowing identification of individuals or households is securely kept at the IFPRI offices in password-protected files. This permits the investigators to follow up with the respondents, if necessary. All information collected has been used and will continue to be used in a manner that does not allow the identification of participants.

4. Baseline Survey Household Descriptors

The quantitative baseline household survey was implemented in Adamawa and Kwara states from February 1 to 17, 2023. The objective of this baseline household survey was to present an overview of the farm households participating in the study, which has informed the IE study, including the design of the endline survey implementation and the overall implementation of the intervention. As noted previously, it is important to establish that there are no preexisting differences in key

characteristics between the treatment and control clusters (Abate et al., 2023). This ensures that there are no conflating drivers of differences in the outcomes of interest between the treatment and control groups. The balance between the groups was established in the earlier section. This ensures that there is *internal* validity in the evaluation design and results.

Another important consideration for this type of IE is the *external* validity of the findings, meaning the extent to which the findings can be applied beyond the communities or states selected for the study. The evaluation team selected Adamawa and Kwara in part because they represent two different types of states in northern Nigeria, which ensures that the findings can have some applicability in both the northwest and northeast regions, and among states with different features. In the following descriptions of farm households, the similarities, and differences between the two states are highlighted, especially for those household characteristics that are likely to influence farmers' behavior, access to knowledge and farm practices, and outcomes.

4.1 Household characteristics

Table 3 summarizes the main household head characteristics of the households surveyed. Overall, the data in this table show that while there are similarities between Adamawa and Kwara in household head age and primary source of income, there are distinct differences in the roles of women, marital practices, and education levels, which may reflect cultural, economic, or policy variations between the two regions. Although household size averages are similar in Adamawa (5.8) and Kwara (5.96), female heads of households and particularly female plot managers are more predominant in Adamawa than in Kwara, suggesting that women in Adamawa are more active participants in agriculture.

Table 3 Characteristics of survey household heads

	Adamawa		Kwara			Total	
Characteristic	Mean	SD	Mean	SD	*P* value	Mean	SD
HH size (number)	5.80	3.02	5.96	3.34	0.34	5.88	3.19
Female HH head	0.08	0.27	0.02	0.15	0.00**	0.53	0.22
Age of HH head	43.99	13.60	43.87	14.10	0.87	43.93	13.85
Female plot manager	0.49	0.50	0.43	0.49	0.00**	0.46	0.50
HH head ages 18–29 years	0.13	0.34	0.13	0.34	0.87	0.13	0.34
HH head ages 30–59 years	0.71	0.45	0.69	0.46	0.51	0.70	0.46
HH head ages 60+ years	0.16	0.36	0.17	0.38	0.51	0.16	0.37
Single HH head	0.05	0.22	0.09	0.29	0.00**	0.07	0.26
Married HH head (monogamous)	0.66	0.47	0.56	0.50	0.00**	0.61	0.49
Married HH head (polygamous)	0.22	0.42	0.34	0.47	0.00**	0.28	0.45
HH head with no formal education	0.17	0.38	0.30	0.46	0.00**	0.24	0.42
HH head with primary education	0.15	0.35	0.21	0.41	0.00**	0.18	0.38
HH head with secondary education	0.43	0.50	0.25	0.44	0.00**	0.34	0.47
HH head with tertiary education	0.25	0.43	0.24	0.43	0.72	0.24	0.43
HH head source of income: agriculture	0.83	0.37	0.94	0.24	0.00**	0.89	0.32
HH head source of income: off farm	0.16	0.37	0.06	0.24	0.00**	0.11	0.31

Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey (2023).
Note: ** significant at the 1% level; * significant at the 5% level. HH = household.

Interestingly, the average age of household heads, as well as the age distribution, is similar across both regions, with the majority of household heads being between 30 and 59 years old. In terms of marital status, the majority of houseful heads are married and in monogamous relationships, with Adamawa having a lower percentage of polygamous marriages (22.4 percent) compared with Kwara (33.6 percent). A small percentage have never been married, with Kwara reporting a higher figure (9.16 percent).

The education levels vary, with no formal education being more common in Kwara (29.9 percent) than in Adamawa (17.29 percent). However, a significant portion of the population has completed secondary education, particularly in Adamawa (43.43 percent). Agricultural income is the primary source for the vast majority in both regions and is notably higher in Kwara (93.98 percent). Off-farm income is more prevalent in Adamawa (16.12 percent), suggesting a more diversified income base compared with that of Kwara.

Table 4 presents the main source of energy for lighting in Adamawa and Kwara, highlighting a significant difference between these two regions. In Adamawa, the great majority of households (81.29 percent) rely on traditional methods (torches/fire skewers), whereas in Kwara, households rely mainly on electricity (64 percent). This suggests an unequal access to modern energy sources. Solar electricity is also more commonly used in Kwara (10.44 percent) than in Adamawa (2.14 percent), further supporting the notion of more advanced energy solutions in Kwara. This finding indicates a significant divide between the two regions in energy access and utilization. The relatively high standard deviations for electricity and torch/fire in Kwara and Adamawa, respectively, suggest a substantial variation within each region in lighting choices or availability, which is likely influenced by factors such as geographic location, infrastructure, and economic conditions.

Table 4 Lighting energy source

Main source of lighting	Adamawa		Kwara		*P* value	Total	
	Mean	SD	Mean	SD		Mean	SD
Electricity	0.13	0.34	0.64	0.48	0.00**	0.38	0.49
Private generator	0.03	0.16	0.06	0.24	0.00**	0.04	0.20
Solar electricity	0.02	0.14	0.10	0.31	0.00**	0.06	0.24
Kerosene	0.00	0.00	0.001	0.04	0.32	0.001	0.03
Candles	0.004	0.07	0.001	0.04	0.32	0.003	0.05
Torch/skewers	0.81	0.39	0.20	0.40	0.00**	0.50	0.50

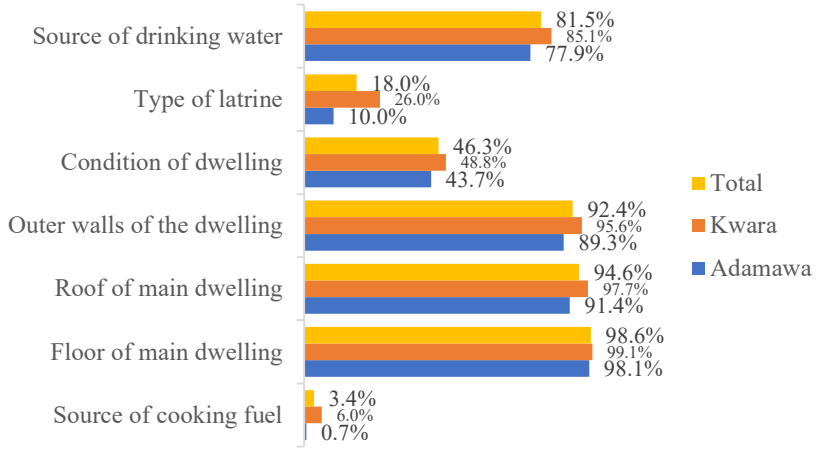
Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey (2023).
Note: ** significant at the 1% level; * significant at the 5% level.

4.2 Housing and land acquisition

Figure 3 illustrates the existence of improved dwelling structure and housing conditions. Across all indicators, Kwara shows a higher percentage of households with improved housing conditions, which

suggests better infrastructure and living standards compared with Adamawa. Nevertheless, both states have relatively good access to drinking water, improved dwelling conditions, and basic dwelling amenities like roofs and floors.

Figure 3 Improved structure of dwelling and house condition



Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey, 2023.

Note: "Cooking fuel" includes electricity, liquified petroleum gas, natural gas, and kerosene; "floor of the main dwelling" includes concrete/bricks, wood, and mud; "roof of the main dwelling" includes metal/zinc, wood, calamine/cement fiber, cement, and roofing shingles; "outer wall of the dwelling" includes stone with mud, uncovered adobe, plywood, reused wood, cement, stone with lime/cement, bricks, cement blocks, and covered adobe; "condition of dwelling" refers to no sign of damage**; "**type of latrine" includes flush to septic tank/flush to sewage and ventilated improved pit latrine**; "**source of drinking water" includes piped into dwelling, piped to yard/plot, piped to neighbor, public tap/standpipe, tube well or borehole, protected well, protected spring, rainwater, tanker truck, and cart with small tank.

Data presented in Table 5 suggest that while inheritance remains the dominant mode of land acquisition (68.96 percent), there are significant regional differences in land tenure and renting practices. The overall higher costs of rent in Kwara, along with the greater role of local leaders in land distribution and the lower percentage of rented land, points to possible distinct land management practices.

Table 5 Land acquisition

How plot was acquired in the last season	Adamawa		Kwara			Total	
	Mean	SD	Mean	SD	*P* value	Mean	SD
Granted by local leaders	0.03	0.18	0.11	0.32	0.00**	0.07	0.26
Inherited	0.65	0.48	0.73	0.45	0.00**	0.69	0.46
Through family of spouse	0.03	0.17	0.01	0.09	0.00**	0.02	0.14
Purchased with title	0.05	0.23	0.03	0.18	0.02*	0.04	0.20
Purchased with no title	0.02	0.15	0.01	0.09	0.00**	0.02	0.13
Leasehold (long term)	0.01	0.11	0.03	0.17	0.00**	0.02	0.14
Rent (short term)	0.17	0.38	0.05	0.22	0.00**	0.11	0.32
Sharecropping	0.002	0.04	0.02	0.12	0.00**	0.01	0.09
Mean yearly rent (in 1000s)	31.39	31.65	46.43	64.14	0.00**	35.90	44.39

Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey (2023).
Note: ** significant at the 1% level; * significant at the 5% level.

4.3 Plot characteristics

Table 6 lists some of the main characteristics of household cowpea plots, showing again a clear distinction between the two states. In Kwara, the average plot size is 4 hectares, which is double the size of those in Adamawa, where plots average 1.9 hectares. This difference points to a disparity in land ownership or land use practices between the two regions, with Kwara possibly having larger farming operations. In addition, farmers in Adamawa face longer distances to reach their plots, with an average travel time of 39.5 minutes, compared with 33.3 minutes in Kwara. This longer distance could affect Adamawa farmers' efficiency and access to their fields. Adamawa's plots are prone to deeper flooding, with average flood depths reaching 1.9 feet during the season, which is more than twice the depth experienced in Kwara. This finding suggests that Adamawa's agricultural land is more vulnerable to flooding, potentially affecting crop yield and farming outcomes. This highlights the importance of accounting for any flooding during the production cycle when the RCT is implemented.

Table 6 Plot characteristics

Plot characteristic	Adamawa		Kwara		*P* value	Total	
	Mean	SD	Mean	SD		Mean	SD
Plot size in hectares per household	1.94	1.82	4.00	4.50	0.00**	2.93	3.54
Distance of plots from home (in minutes)	39.40	31.24	33.28	31.26	0.00**	36.43	31.39
Usual flood depth during the flooding season (in feet)	2.04	6.45	0.99	4.85	0.00**	1.53	5.75
Plot type							
Homestead	0.08	0.27	0.05	0.22	0.01*	0.07	0.25
Cultivable/arable land	0.79	0.41	0.90	0.30	0.00**	0.84	0.36
Pasture	0.01	0.09	0.01	0.10	0.41	0.01	0.09
Bush/forest	0.11	0.32	0.02	0.14	0.00**	0.07	0.25
Waste/nonarable land	0.002	0.04	0.00	0.00	0.17	0.001	0.03
Land in riverbed	0.005	0.07	0.02	0.12	0.02*	0.01	0.10
Another residential/commercial plot	0.001	0.03	0.00	0.00	0.33	0.001	0.02
Cultivable pond	0.001	0.03	0.00	0.00	0.33	0.001	0.02
Soil type							
Clay	0.05	0.22	0.01	0.10	0.00**	0.03	0.17
Loam	0.18	0.39	0.40	0.49	0.00**	0.29	0.45
Sandy	0.25	0.43	0.09	0.229	0.00**	0.18	0.38
Clay-loam	0.24	0.43	0.16	0.37	0.00**	0.20	0.40
Sandy-loam	0.27	0.44	0.33	0.47	0.00**	0.30	0.46

Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey (2023).
Note: ** significant at the 1% level; * significant at the 5% level.

The plot land characteristics also vary, with Kwara having a higher percentage of cultivable or arable land at 90.03 percent, compared with 79.09 percent in Adamawa. However, Adamawa has more bush or forest areas, which might indicate either a greater amount of uncultivated land or a preference for certain crops that can be grown alongside forested areas. Soil type distribution highlights Kwara's agricultural advantage, with a significant portion loam soil, which is typically fertile and good for a variety of crops. In contrast, Adamawa's soil types are more varied, with sandy, clay-loam, and sandy-loam soils, each presenting unique challenges and benefits for agriculture.

Overall, the agricultural landscape in Kwara appears to be characterized by larger, more arable plots with more uniform, fertile soil, which is conducive to farming. In contrast, Adamawa's agricultural scene is marked by smaller plots, greater travel distances, and a higher risk of flooding.

Table 7 highlights the share of crops on total cropped land in Adamawa and Kwara. As expected, cowpea is the major crop grown in Adamawa and Kwara. Specifically, 96 percent and 98 percent of households in Adamawa and Kwara, respectively, reported that they planted cowpea. Interestingly, intercropping is a more common household farm practice in Adamawa (60 percent) than in Kwara (21 percent). Planting maize along with cowpea was reported by 50 percent in Adamawa state and only 19 percent in Kwara state. Several other crops—Bambara nut, benniseed sesame, cashew, cassava, cotton, ewedu, ground nut, guinea corn, Irish potato, melon, millet, okra, pepper, potato, rice, sorghum, soybean/soya, sweet potatoes, tomatoes, and yam—are grown in these states, but compared with cowpea and maize, they represent only a small percentage, with 22 percent in Adamawa and 24 percent in Kwara.

Table 7 Share of crops on total cropped land

Crop	Adamawa		Kwara			Total	
	Mean	SD	Mean	SD	*P* value	Mean	SD
Practice of intercropping (%)	0.60	0.49	0.21	0.41	0.00**	0.41	0.49
Cowpea	0.96	0.19	0.98	0.14	0.01*	0.97	0.17
Maize	0.50	0.50	0.19	0.40	0.00**	0.35	0.48
Other crops	0.22	0.41	0.24	0.43	0.21	0.23	0.42

Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey (2023).
Note: ** significant at the 1% level; * significant at the 5% level.

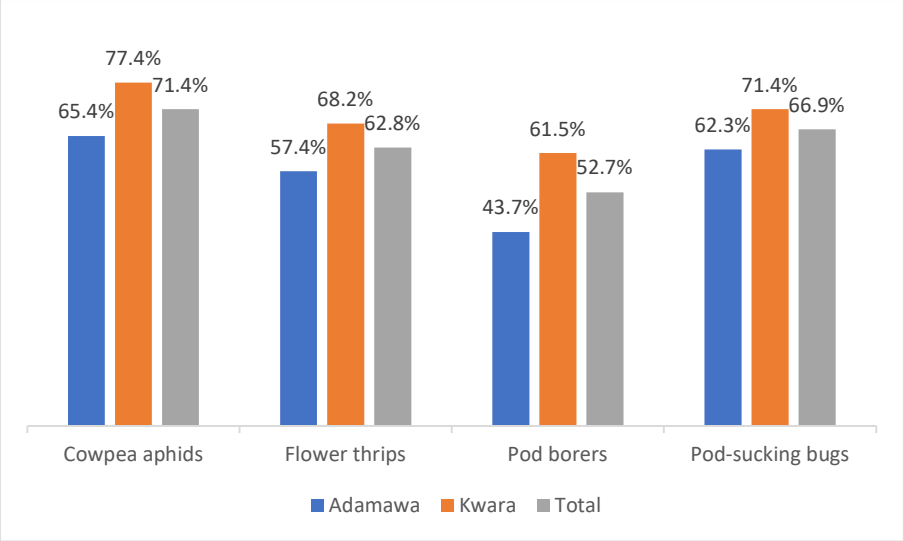
5. Pesticide and Herbicide Applications

5.1 Insect and weeds infestation

Insect and weed infestation are significant challenges to cowpea production and impact crop yield and quality. Pod borer, flower thrips, cowpea aphids, and pod-sucking bugs are the main pests attacking cowpea. Weeds compete with crops for resources like sunlight, water, and nutrients, negatively affecting their growth and development. Farmers use pesticides to combat these challenges.

Figure 4 illustrates the pests that farmers were targeting with pesticide applications in Adamawa and Kwara, and an aggregate total for both regions.

Figure 4 Insect infestations targeted by pesticides



Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey (2023).

Farmers in both states reported that they mostly used pesticides to control aphids, closely followed by pod-sucking insects. The findings show that 62.3 percent of farm households in Adamawa and 71.4 percent in Kwara controlled this insect with pesticides. Flower thrips, another prominent pest, were controlled with pesticide by 57.4 percent of farmers in Adamawa and 68.2 percent in Kwara. Based on the survey, farmers in both states experienced pod-borer infestation. Farmers tend to use pesticides to control the pod borer as well, with 43.7 percent of farm households in Adamawa and 61.5 percent of farmers in Kwara reporting use of pesticides for controlling the pod borer.

Table 8 presents a comparative overview of the use, application methods, quantity, and cost of pesticides and herbicides in Adamawa, Kwara, and a combined total for both regions. Farmers report high pesticide use, although it is slightly more prevalent in Kwara, with 98 percent of farmers using pesticides, compared with 92 percent in Adamawa. The situation is similar for herbicides, with Kwara at 84 percent and Adamawa at 87 percent, although this difference is not statistically different. In both regions, nearly all farmers apply pesticides via spraying.

Table 8 Use of pesticides and herbicides

Use of agrochemicals	Adamawa		Kwara			Total	
	Mean	SD	Mean	SD	*P* value	Mean	SD
Use of pesticides	0.92	0.27	0.98	0.13	0.00**	0.95	0.22
Use of herbicides	0.87	0.34	0.84	0.37	0.08	0.85	0.36
Method of application of pesticides: spray	1	0	0.99	0.10	0.00**	0.99	0.07
Average number of sprays	3.0	1.4	6.2	2.7	0.00**	4.6	2.7
Quantity (liter per ha)	3.6	6.1	6.4	9.9	0.00**	5.0	8.3
Quantity (liter per ha) – pod borer only	4.5	7.0	6.4	10.5	0.00**	5.5	9.2
Cost (1,000 naira per ha)							
Pesticides	11.91	20.21	27.85	32.34	0.00**	19.96	28.17
Herbicides	20.29	29.49	24.47	33.82	0.00**	22.36	31.77

Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey (2023).
Note: ** significant at the 1% level; * significant at the 5% level.

Looking at the intensity of application, Kwara farmers spray more frequently, averaging 6.2 times per growing season, which is significantly higher than Adamawa's average of 3 times. This difference could suggest either higher pest pressure in Kwara or a more proactive approach to pest management. The quantity of pesticides used follows the same pattern; Kwara's farmers apply more (6.4 liters per hectare) than those in Adamawa (3.6 liters per hectare). This disparity is also seen in the targeted application against pod-borer insects, with both regions reporting high pesticide use, although Kwara's remains higher. Farmers in Kwara also report higher expenses for both pesticides and herbicides per hectare. The average cost of pesticides in Kwara is 27,850 thousand naira, more than double that of Adamawa, which stands at 11,910 naira. Herbicide use also follows this trend, with Kwara spending 24,400 Naira per hectare compared with Adamawa's 20,290 naira.

These figures underscore the economic investment in agrochemicals and reflect the regional differences in farming practices. Kwara's higher pesticide use, and costs may indicate larger-scale farming or more valuable crops that require greater protection from pests and weeds. Conversely, Adamawa's lower figures could reflect smaller-scale operations or different approaches to pest management.

5.2 Pesticide handling

Table 9 summarizes pesticide handling practices among cowpea farmers in Adamawa and Kwara, detailing behaviors such as reading labels, following instructions, preparing for use, and taking safety measures during and after pesticide application, as well as the storage of pesticides.

Table 9 Pesticide handling

Pesticide handling practices	Adamawa		Kwara			Total	
	Mean	SD	Mean	SD	*P* value	Mean	SD
Read the label before using pesticides	0.45	0.50	0.58	0.49	0.00**	0.52	0.50
Did not read the label before using pesticides	0.52	0.50	0.28	0.45	0.00**	0.39	0.49
Unable to read the label before using pesticides	0.03	0.16	0.13	0.34	0.00	0.09	0.28
Got help from others who can read	0.45	0.51	0.79	0.41	0.00**	0.74	0.44
Followed instructions on the label at all times	0.56	0.50	0.80	0.40	0.00**	0.71	0.45
Sometimes followed instructions on the label	0.42	0.49	0.20	0.40	0.00**	0.28	0.45
How do you prepare pesticides?							
With bare hands	0.17	0.38	0.09	0.29	0.00**	0.13	0.33
With hand gloves	0.50	0.50	0.48	0.50	0.47	0.49	0.50
With a stick (but bare hands)	0.34	0.47	0.26	0.44	0.00**	0.30	0.46
With a stick and wearing gloves	0.63	0.48	0.61	0.49	0.35	0.62	0.48
While spraying pesticides							
Wears hand gloves	0.66	0.47	0.69	0.46	0.20	0.68	0.47
Wears head cover	0.50	0.50	0.62	0.49	0.00**	0.56	0.50
Wears face shield	0.60	0.49	0.69	0.46	0.00**	0.65	0.48
Wears eye protection	0.34	0.48	0.44	0.50	0.00**	0.40	0.49
Wears long-sleeved shirt	0.82	0.39	0.88	0.32	0.00**	0.85	0.35
Wears full-length trouser	0.91	0.29	0.93	0.25	0.05	0.92	0.27
Wears sandal/shoes	0.87	0.34	0.91	0.28	0.00**	0.89	0.31
After applying pesticides							
Wash hands after spraying	0.95	0.22	0.96	0.19	0.14	0.96	0.20
Wash face after spraying	0.93	0.25	0.94	0.23	0.22	0.94	0.24
Take bath/shower after spraying	0.94	0.24	0.96	0.20	0.08	0.95	0.22
Change clothes after spraying	0.93	0.25	0.94	0.23	0.31	0.94	0.24
Keep medicine/food items in pesticide bottles after washing them out	0.26	0.44	0.18	0.38	0.00**	0.21	0.41
Kept pesticide bottles in the same place where medicine or food is kept	0.18	0.38	0.09	0.29	0.00**	0.13	0.34

Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey (2023).
Note: ** significant at the 1% level; * significant at the 5% level.

In Adamawa, almost half of the farmers (45.45 percent) read the label before spraying pesticides, which is lower than in Kwara, where 56.7 percent do so. A low number of farmers in Adamawa reported not being able to read (2.69 percent), which is markedly less than those in Kwara (15.3 percent), although this difference is not statistically significant. Most farmers in Kwara (82.49 percent) seek help from others who can read, indicating a community approach to overcoming literacy barriers; this practice is less common in Adamawa (45.83 percent). Strictly following the instructions on the label is higher in Kwara (80.8 percent) than in Adamawa (53.37 percent). This finding could imply a higher level of compliance with safety protocols in Kwara and better understanding of the importance of following instructions.

Regarding preparation, the majority of farmers in both regions report using gloves and a stick to stir the pesticides, suggesting an awareness of the need for protective measures. When spraying

pesticides, a similar trend is observed, with a large majority reporting wearing protective clothing and equipment. Post-application safety practices such as washing hands and face or taking a bath are nearly universal in both regions, showing a good level of safety awareness. Changing clothes after spraying is also similarly high in both regions. However, storage of pesticides is a concern, as a small percentage of farmers in both regions reported keeping medicine or food items in washed-out pesticide bottles or storing pesticide bottles in the same place as food or medicine.

Overall, while there are differences between Adamawa and Kwara, there appears to be a high adherence to most safety practices, although there are concerns about literacy and storage safety. There is a potential association between these practices and the self-reported health symptoms shown in Table 10. However, these associations do not prove causation, and further investigation is necessary to fully understand the relationship between pesticide handling practices and farmers' health in these regions.

6. Health and Pesticide Applications

Household members who worked in cowpea plots answered questions about their experience with some symptoms that can be associated with post-pesticide application, including dizziness, nausea, diarrhea, fever, convulsion, shortness of breath, skin diseases, or joint pain (Kim, Kabir, and Jahan, 2017). It is important to note that while these symptoms may be associated with pesticide use, the survey did not seek to establish a clear causality between the health reports and farmer practices such as pesticide handling or proximity to pesticide storage. Table 10 summarizes the responses of all household members surveyed. Their answers appear to show a high prevalence of some of the health symptoms that may be associated with pesticides.

Table 10 Farmers' self-reported symptoms

	Adamawa		Kwara			Total	
	Mean	SD	Mean	SD	*P* value	Mean	SD
Self-reported symptoms experienced							
Headache	0.34	0.47	0.61	0.49	0.00**	0.50	0.50
Dizziness	0.10	0.30	0.05	0.21	0.00**	0.07	0.25
Nausea	0.03	0.18	0.02	0.14	0.10	0.02	0.16
Diarrhea	0.04	0.20	0.01	0.11	0.00**	0.02	0.15
Fever	0.74	0.44	0.32	0.47	0.00**	0.50	0.50
Convulsion	0.01	0.08	0.004	0.06	0.62	0.001	0.07
Shortness of breath, wheezing, coughing	0.04	0.18	0.09	0.29	0.00**	0.07	0.25
Skin disease	0.01	0.11	0.06	0.24	0.00**	0.04	0.20
Joint pain	0.14	0.35	0.54	0.50	0.00**	0.38	0.48
Health effects							
Number of days symptom lasted	11.77	14.39	5.71	4.84	0.00**	8.22	10.40
Symptom prevented work	0.85	0.35	0.73	0.45	0.00**	0.78	0.41
Number of days symptoms prevented work	9.16	10.92	5.58	6.01	0.00**	7.20	8.77
Sought medical treatment for symptoms	0.97	0.16	0.93	0.26	0.00**	0.95	0.23
Incurred expenses to address symptoms	0.99	0.09	0.99	0.07	0.42	0.99	0.08
Medical expenses incurred to address symptoms (1,000 naira)	9.93	17.08	5.48	9.78	0.00**	7.36	13.53
Medical expenses incurred to address symptoms (US dollars)	20.89	35.93	11.53	20.58	0.00**	15.48	28.47

Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey (2023).
Note: ** significant at the 1% level; * significant at the 5% level.
At the time of the survey, the exchange rate was N475.30 Nigerian Naira to 1 US Dollar.

The data point to striking disparities between Adamawa and Kwara farmers self-reporting symptoms and the health impacts associated with pesticide use. Adamawa's farmers report more severe symptoms, with fever being notably more prevalent (74 percent) and symptoms lasting longer (12 days), which in turn lead to more days off work (9 days). In contrast, Kwara, while still affected, reports lower incidences, and impacts of these health symptoms, except for headaches and joint pain. This is despite the fact that Kwara farmers spray, on average, 6.2 times and apply 8.4 liters per ha, almost double their counterparts in Adamawa, as shown in Table 8.

These differences could be attributed to a variety of factors, such as the types of agrochemicals used, the methods of application, the availability of personal protective equipment, or more notably, the farmers' baseline (existing health conditions). Moreover, the higher medical expenses reported in Adamawa could reflect differences in the cost of healthcare between the regions, the severity of symptoms experienced, or a combination.

It is crucial to note that while the data suggests a correlation between the use of agrochemicals and the reported health symptoms, it does not establish causation. The associations observed require further investigation to determine the underlying causes and to identify whether these symptoms are directly attributable to agrochemical use or if other confounding factors are at play.

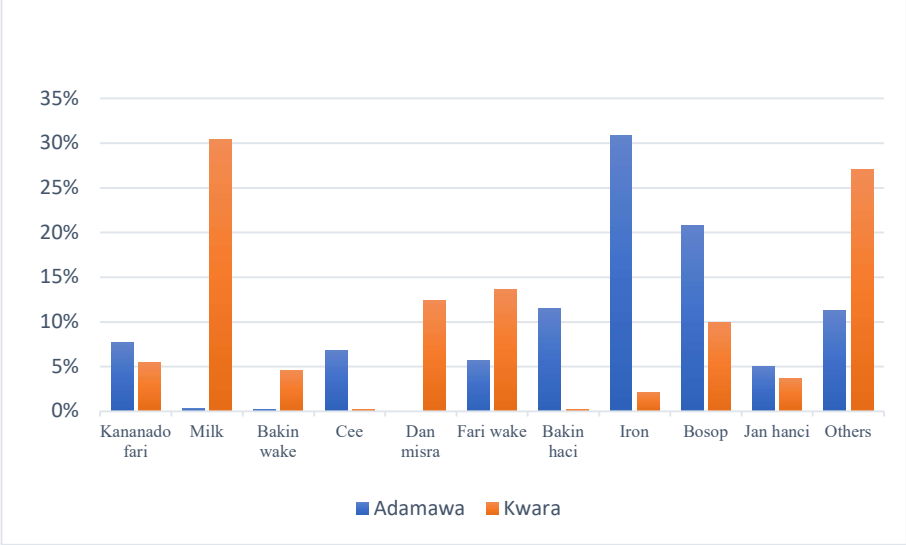
7. Production and Yields

Cowpea production plays a vital role in providing income and nutrition for households in Nigeria. It is considered a resilient and sustainable crop because of its ability to thrive in various agroecological conditions and its tolerance to drought and heat stress (Carvalho et al. 2017).

7.1 Cowpea variety preferences

Figure 5 provides information on the dissimilar choice of cowpea varieties planted in Adamawa and Kwara. The most popular variety in Adamawa is “Iron,” with about 30.8 percent of farmers planting it, followed by the variety “Bosop,” at about 20.8 percent. In contrast, in Kwara, the most planted variety is “Milk,” chosen by 30.4 percent of farmers, followed closely by the variety labeled “Others” at 27.0 percent, indicating a diversity of less-common varieties.

Figure 5 Cowpea varieties planted



Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey (2023).

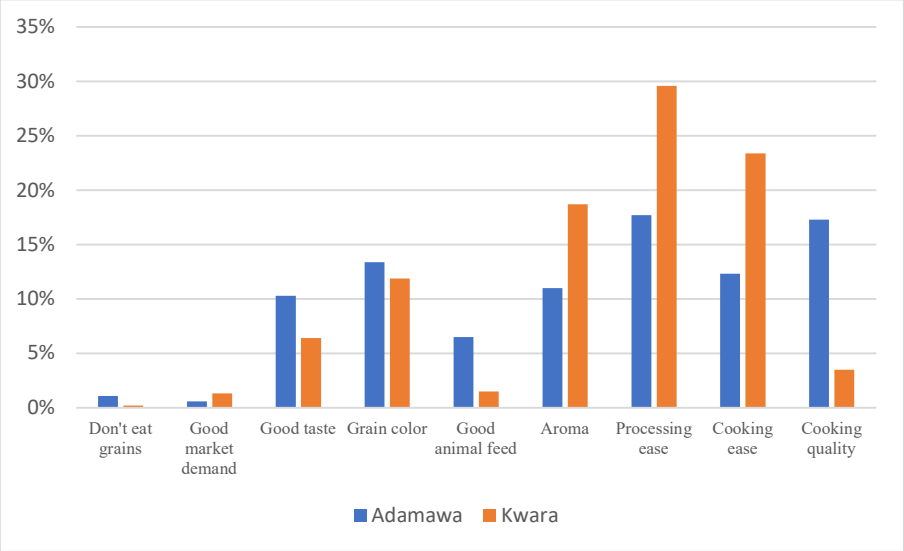
Interestingly, certain varieties appear to have a strong regional preference; for example, Milk is the most favored variety in Kwara (30 percent) but is apparently unknown in Adamawa. Conversely, Iron is far more popular in Adamawa (30.8 percent) than in Kwara. It is possible that the same variety is known locally under different names, but this was not verified.

This distribution of cowpea variety choices could be influenced by factors such as local climate conditions, soil types, pest resistance, market demand, and seed availability. The variety categorized

as “Others” suggests that a considerable number of farmers in both regions are growing cowpea varieties that are not mainstreamed or widely recognized. This could indicate localized adaptation or heritage varieties.

These preferences could have implications for agricultural extension services, seed distribution programs, and efforts to improve cowpea yields and pest resistance. The baseline survey also explored farmers’ cowpea seed preferred traits for production and consumption. As observed in Figure 6 for production traits, farmers in both states appear to have a high preference for early maturity varieties.

Figure 6 Farmers’ preferred variety traits

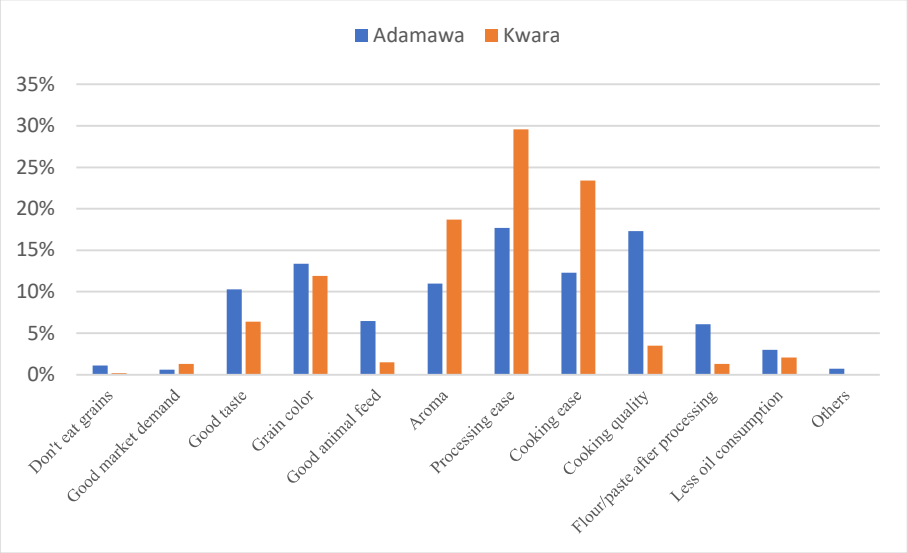


Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey (2023).

In terms of consumption traits,

Figure 7 revealed that Kwara respondents were more likely to accept cowpea legumes as a food source, as they reported better market demand, aroma, easier processing, and cooking, while farmers in Adamawa appreciated cowpeas’ good taste, appealing grain color, good cooking quality, suitability for making flour/paste after processing, and low oil consumption.

Figure 7 Farmers' preferred consumption traits



Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey (2023).

7.2 Varieties planted and PBR awareness

As shown in, the great majority of farmers surveyed in both Adamawa (92 percent) and Kwara (87 percent) plant traditional cowpea varieties. However, a small but notable number of farmers plant improved or certified seeds. Given the current lack of availability of PBR cowpea seed in these states, the percentage of plots planted with PBR cowpea barely reached 1 percent, a finding consistent with the selection of these states for the study.

Table 11 Cowpea varieties planted

	Adamawa		Kwara			Total	
Type of seed planted	Mean	SD	Mean	SD	*P* value	Mean	SD
Improved seed	0.03	0.18	0.10	0.30	0.00**	0.06	0.25
Conventional cowpea	0.92	0.27	0.87	0.33	0.00**	0.90	0.30
PBR cowpea	0.001	0.03	0.01	0.09	0.00**	0.005	0.07

Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey (2023).
Note: ** significant at the 1% level; * significant at the 5% level.

7.3 Yield

The household survey collected data on total cowpea harvested by plot, quantities discarded due to pest infestation or other reasons, the proportion consumed or sold, and gross yields per hectare (quantity harvested in kg divided by plot size in hectare). This information, summarized in Table 12, refers to cowpea production harvested in November and December 2022, with a few observations from October 2022.

Table 12 Mean levels of cowpea production and yield by state

Cowpea production and yield	Adamawa		Kwara			Total	
	Mean	SD	Mean	SD	*P* value	Mean	SD
Quantity per plot produced (kg/plot)	343.97	335.76	865.57	405.65	0.00**	644.01	457.14
Quantity discarded (kg)	43.16	115.03	97.58	194.55	0.00**	69.77	161.24
Proportion of home consumption (%)	13.49	14.21	9.12	8.32	0.00**	10.79	11.15
Proportion of production sold (%)	32.92	30.94	47.87	27.06	0.00**	42.17	29.50
Proportion of other things	50.91	36.17	45.07	28.15	0.00**	47.30	31.56
Gross yield (kg per ha)	287.37	320.66	454.69	388.29	0.00**	383.53	370.34

Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey (2023).
Note: ** significant at the 1% level; * significant at the 5% level. "Proportion of other things" includes proportions discarded, lost, gifted, retained for seed stock, paid to labor, paid to owner, and stored.

Table 12 shows the mean values of cowpea production and yield in Adamawa and Kwara, which demonstrate a high disparity in agricultural productivity between the two states. Kwara boasts a significantly higher average quantity of cowpeas produced at 865.57 kg per plot, dwarfing Adamawa's 343.97 kg. The gross yield per hectare tells a similar story, with Kwara achieving 454.69 kg per hectare, almost double that of Adamawa (287.37 kg/ha). Even in terms of market engagement, Kwara's farmers sell a larger proportion of their produce, indicating a more commercially oriented approach to farming compared with Adamawa, where a higher percentage is retained for home consumption.

However, the data also show relatively high standard deviations across all categories in both states, particularly in Kwara. These high standard deviations highlight the diversity and inequality within the agricultural sectors of Adamawa and Kwara. Such disparities would require further analysis to understand the underlying causes, which could range from individual farmer decisions to systemic issues in agricultural support and infrastructure.

While some farmers enjoy high yields and production, others struggle with much less, pointing to uneven access to resources, differences in land quality and farming practices, or the impact of external factors like climate variation or market access. These figures suggest that Kwara's farming practices may be more intensive and possibly more market oriented than those in Adamawa, leading

to higher overall production and yields. The significant differences between the two states demand further investigation to understand the underlying factors contributing to these disparities.

8. Marketing, Costs, and Revenues

8.1 Cowpea markets

The data presented in Table 13 **Cowpea Marketing** show some significant differences in the structure and maturity level of cowpea markets in Adamawa and Kwara. Like other indicators, it seems to signal that the market operations in Kwara are more developed compared with those in Adamawa. This is evidenced first by the dominance of wholesalers, which is significantly higher in Kwara (68.8 percent) than in Adamawa (55.5 percent). Such a disparity suggests a more consolidated and potentially advanced market structure in Kwara. In addition, the proportion of village collectors is smaller in Kwara compared with Adamawa. This difference further underscores Kwara's leaning toward a more modern market system, as the use of village collectors typically signals more traditional, small-scale trade practices prevalent in less-developed markets. Moreover, the mode of transportation to the point of sale reinforces this view; in Kwara the majority (69.2 percent) use vans, trucks, or motorcars, a much higher percentage than in Adamawa (49.2 percent). Last, the communication patterns between farmers and sellers in Kwara, where 39 percent of farmers contact the seller via phone before sale—a figure three times higher than in Adamawa—may indicate a relatively more sophisticated market engagement. This not only indicates the likelihood of a better market infrastructure and logistics in Kwara but also aligns with the characteristics of a more modern, efficient market system. Of course, these are descriptive statistics that would require further analytical validation.

Table 13 Cowpea Marketing

Marketing factors	Adamawa		Kwara			Total	
	Mean	SD	Mean	SD	*P* value	Mean	SD
Main buyer of cowpea							
Village collector	0.11	0.31	0.03	0.18	0.00**	0.06	0.23
Wholesaler	0.55	0.50	0.69	0.46	0.00**	0.64	0.48
Retailer	0.1	0.30	0.12	0.32	0.43	0.11	0.31
Consumers	0.09	0.28	0.06	0.24	0.11	0.07	0.25
Others	0.11	0.31	0.08	0.27	0.15	0.09	0.29
Did not sell	0.04	0.20	0.02	0.14	0.06	0.03	0.17
Reason for choice of buyers							
Pay high/fair price	0.24	0.43	0.14	0.35	0.00**	0.17	0.38
Buys in bulk	0.22	0.41	0.38	0.49	0.00**	0.33	0.47
Buys limited quantity	0.02	0.12	0.002	0.04	0.01*	0.007	0.08
Makes advance payment	0.003	0.05	0.02	0.15	0.02*	0.02	0.13
Makes immediate payment	0.34	0.47	0.41	0.49	0.04*	0.38	0.49
Lives nearby	0.13	0.33	0.03	0.16	0.00**	0.06	0.24
No other options	0.06	0.24	0.01	0.11	0.00*	0.03	0.17
Contact buyer before sale							
Phone (SMS, call, WhatsApp)	0.11	0.31	0.39	0.49	0.00**	0.29	0.45
Fellow farmer	0.18	0.39	0.07	0.25	0.00**	0.11	0.31
Local/extension agent	0.07	0.25	0.09	0.28	0.38	0.08	0.27
Means of transportation							
Self-carrying	0.10	0.30	0.07	0.25	0.08	0.08	0.27
Van/tractor	0.14	0.35	0.16	0.37	0.34	0.15	0.36
Truck/pickup	0.10	0.31	0.23	0.43	0.00**	0.19	0.39
Motorcar	0.25	0.43	0.29	0.46	0.14	0.28	0.45
Bicycle	0.02	0.14	0.003	0.06	0.02*	0.01	0.09
Motorcycle	0.35	0.48	0.22	0.42	0.00**	0.27	0.44
Wheelbarrow	0.01	0.10	0.00	0.00	0.02	0.003	0.06
Sold at home	0.03	0.16	0.01	0.11	0.13	0.02	0.13
Location of sales							
Farmer's field	0.01	0.08	0.02	0.15	0.06	0.02	0.13
Local retail market	0.16	0.37	0.13	0.34	0.21	0.14	0.35
District wholesale	0.23	0.42	0.18	0.39	0.11	0.20	0.40
Wholesale collection center	0.01	0.12	0.002	0.04	0.01*	0.006	0.08
Virtually	0.00	0.00	0.05	0.07	0.21	0.003	0.06
Open market	0.31	0.46	0.56	0.50	0.00*	0.48	0.50
Own village	0.19	0.39	0.05	0.23	0.00**	0.10	0.30
Others	0.09	0.29	0.04	0.20	0.00**	0.06	0.24

Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey (2023).
Note: ** significant at the 1% level; * significant at the 5% level.

8.2 Labor use

Table *14* **Labor use for cowpea cultivation: number of days by cultivation activities** provides a detailed breakdown of hired and household labor in Adamawa and Kwara, revealing pronounced regional differences and the variability of labor days across agricultural activities.

Table 14 Labor use for cowpea cultivation: number of days by cultivation activities

Activity	Gender	Hired labor use (number of days)						
		Adamawa		Kwara		*P* value	Total	
		Mean	SD	Mean	SD		Mean	SD
Land preparation (ploughing, harrowing, leveling)	Male	2.62	3.24	8.62	8.76	0.00**	6.11	7.60
	Female	1.27	3.10	1.12	4.36	0.53	1.18	3.89
Planting	Male	2.41	2.69	5.33	5.06	0.00**	4.10	4.48
	Female	2.08	2.59	1.94	3.99	0.50	2.00	3.47
Fertilizer application	Male	1.04	1.81	0.99	3.14	0.73	1.01	2.66
	Female	0.64	1.46	0.27	1.42	0.00**	0.42	1.45
Pesticide application	Male	1.78	2.18	6.83	6.91	0.00**	4.72	5.99
	Female	0.40	1.16	1.32	3.42	0.00**	0.94	2.75
Weeding	Male	3.68	5.06	8.01	11.38	0.00**	6.20	9.51
	Female	2.19	4.78	1.87	9.26	0.50	2.00	7.71
Irrigation (channel maintenance)	Male	0.05	0.50	0.03	0.41	0.55	0.04	0.45
	Female	0.10	0.93	0.02	0.41	0.04*	0.05	0.68
Harvest	Male	5.39	27.27	12.46	11.23	0.00**	9.50	19.90
	Female	5.58	29.32	11.09	12.76	0.00**	8.79	21.47
Sorting and packing	Male	2.07	2.49	4.27	5.28	0.00**	3.35	4.47
	Female	1.74	2.74	3.78	4.64	0.00**	2.92	4.08
Uprooting of plants	Male	1.66	2.79	2.69	6.40	0.00**	2.26	5.23
	Female	1.78	3.40	1.21	2.69	0.00**	1.45	3.02
Activity		**Household labor use (number of days)**						
Land preparation (ploughing, harrowing, leveling)	Male	6.78	6.95	10.58	8.82	0.00**	8.91	8.27
	Female	5.06	5.83	7.79	9.42	0.00**	6.51	8.05
Planting	Male	4.08	3.66	5.20	2.02	0.00**	4.71	4.26
	Female	3.78	3.31	4.72	4.67	0.00**	4.28	4.11
Fertilizer application	Male	1.05	1.93	0.72	2.02	0.00**	0.86	1.99
	Female	0.83	1.62	0.61	2.11	0.07	0.71	1.90
Pesticide application	Male	3.37	4.36	7.26	7.22	0.00**	5.56	6.43
	Female	2.19	3.74	6.27	8.50	0.00**	4.35	6.99
Weeding	Male	6.66	6.83	7.71	7.77	0.00**	7.25	7.39
	Female	5.88	6.08	6.38	7.75	0.26	6.15	7.02
Irrigation (channel maintenance)	Male	0.04	0.27	0.01	0.16	0.01*	0.02	0.21
	Female	0.07	0.37	0.01	0.17	0.00**	0.04	0.28
Harvest	Male	7.98	8.70	14.26	11.39	0.00**	11.50	10.76
	Female	6.25	6.49	14.80	11.18	0.00**	10.79	10.21
Sorting and packing	Male	3.56	3.65	4.62	4.52	0.00**	4.16	4.20
	Female	2.89	2.96	4.84	4.72	0.00**	3.93	4.11
Uprooting of plants	Male	3.02	3.66	2.17	3.24	0.00**	2.54	3.45
	Female	2.44	3.28	2.15	3.44	0.17	2.29	3.37

Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey (2023).
Note: ** significant at the 1% level; * significant at the 5% level.

Hired labor use in Adamawa and Kwara shows a regional difference and the variability of labor days across agricultural activities. Male labor in Kwara is notably more prominent, especially in land preparation, pesticide application, weeding, and harvest, where the mean number of days far exceeds those in Adamawa. For example, the average days for male labor during the harvest in

Kwara is 12.46 days, with a standard deviation of 11.23, suggesting a wide range of labor days, possibly due to different farm sizes or crop intensities. Female labor, while less than male labor in both regions, also shows significant engagement, particularly in Adamawa, where the means and standard deviations for activities like planting and weeding are relatively high.

The household labor data in

Table ***14*** **Labor use for cowpea cultivation: number of days by cultivation activities** complements the insights into agricultural labor use in Adamawa and Kwara. In both regions, the involvement of household labor is significant, particularly for female labor in activities such as land preparation, weeding, and harvesting. For instance, female household labor in Kwara for harvest averages at 14.26 days, with a high standard deviation, indicating a considerable commitment and variability. The household labor in both regions is most prominent in land preparation, pesticide application, weeding, and harvesting, showing higher mean days, which reflects a more intensive use of household labor, especially in labor-intensive tasks.

When comparing household labor to hired labor, it is evident that household labor is heavily used for certain tasks. This is particularly true for tasks traditionally associated with female labor, such as weeding, harvesting, and uprooting plants, where the mean number of days is quite high. In contrast, hired labor is more commonly used for activities that might require specialized skills or additional workers, such as irrigation and weeding, particularly in Kwara.

The high standard deviations across activities for both household and hired labor suggest a diverse range of labor requirements, which could be due to various factors such as farm size, crop type, or seasonal labor demands. The consistently higher figures for Kwara in both household and hired labor categories could imply more extensive agricultural operations or a greater reliance on both household and external labor sources for farming activities.

Overall, the data suggests a significant division of labor between household and hired labor, with each playing distinct roles in the agricultural processes of Adamawa and Kwara. The reliance on household labor, especially among females, also highlights the social and economic roles within agricultural communities.

9. Household Food Security

Food security is a critical global concern that encompasses the availability, accessibility, and utilization of nutritious food for individuals and communities (Berry et al., 2015). It is a multifaceted

issue influenced by various factors such as agricultural productivity, climate change, economic conditions, and social inequalities (Amare et al. 2021; Islam & Kieu 2020).

Table **15 Food insecurity** offers insights into the state of household food security in Adamawa and Kwara using FAO's Food Insecurity Experience Scale (FIES), which measures the severity of food insecurity based on individuals' direct experiences and reported difficulties in accessing food. FIES is an experience-based metric comprising eight questions that assess various degrees of food insecurity over the previous 12 months, focusing on respondents' self-reported food-related behaviors and experiences associated with increasing difficulties in accessing food.

Table 15 Food insecurity

Food insecurity	Adamawa		Kwara		*P* value	Total	
	Mean	SD	Mean	SD		Mean	SD
FIES – secure	0.79	0.41	0.86	0.34	0.00**	0.83	0.37
FIES – mildly insecure	0.19	0.39	0.13	0.34	0.02*	0.15	0.36
FIES – moderately insecure	0.01	0.08	0.00	0.00	0.06	0.002	0.05
FIES – severely insecure	0.01	0.12	0.01	0.09	0.44	0.01	0.10
Experience of household food insecurity in the past 12 months							
Was there a situation of not enough food for the HH	0.51	0.50	0.21	0.41	0.00**	0.36	0.48
Causes of situation							
Inadequate household stocks due to drought/poor rains	0.11	0.32	0.23	0.42	0.00**	0.15	0.35
Inadequate household food stocks due to crop pest damage	0.26	0.44	0.13	0.34	0.00**	0.22	0.42
Inadequate household food stocks due to small land size	0.10	0.30	0.03	0.20	0.03*	0.08	0.27
Inadequate household food stocks due to lack of farm inputs	0.17	0.38	0.23	0.42	0.13	0.19	0.39
Inadequate food stock from farm due to conflict/security	0.02	0.13	0.03	0.18	0.22	0.02	0.15
Food in the market was expensive	0.16	0.37	0.13	0.34	0.36	0.15	0.36
Unable to reach the market due to conflict/security	0.003	0.05	0.01	0.08	0.51	0.004	0.06
No food in the market	0.04	0.19	0.01	0.12	0.14	0.03	0.18
Lack of money	0.75	0.43	0.45	0.50	0.00**	0.67	0.47
Floods/waterlogging	0.05	0.22	0.00	0.00	0.00**	0.04	0.19

Source: IFPRI PBR Cowpea Impact Evaluation Household Baseline Survey (2023).
Note: ** significant at the 1% level; * significant at the 5% level.

In terms of food security, Kwara households fare better, with a higher percentage (86 percent) reporting being secure compared with Adamawa households (79 percent). The total figures suggest that, overall, a significant majority of households in both states are food secure, but there is a notable portion experiencing mild to severe food insecurity.

When examining the causes of food insecurity, the lack of money is the most reported factor in Adamawa (75 percent), which is substantially higher than in Kwara (45 percent). This finding indicates that economic constraints are a significant barrier to food access in Adamawa. Other reasons include inadequate household food stocks due to crop pest damage, with Adamawa households experiencing these issues more frequently than those in Kwara.
It is also notable that some Adamawa households report food insecurity due to conflict and/or security issues, although this is a minor percentage. However, neither Adamawa nor Kwara reports difficulties in reaching the market due to high transportation costs or conflict/security as significant issues, suggesting that access to markets is not a primary food security concern.

10. Summary

The baseline dataset analysis of the IE of the use of PBR cowpea in Adamawa and Kwara provides an overview of cowpea production, household characteristics, health status, and food security status of the cowpea-producing households participating in the study. These findings shed light on prevailing conditions, challenges, and opportunities within the cowpea value chain and its possible implications for the final IE results. It also reveals significant differences between Adamawa and Kwara in cowpea agricultural practices, household characteristics, food security, and market dynamics.

First, the baseline survey findings seem to validate the rationale for public investments in developing the PBR cowpea variety. Pest and weed infestation are common challenges in cowpea production, requiring farmers in both states to use substantial amounts of pesticides and herbicides, although compared with farmers in Adamawa, those in Kwara report higher pesticide application and costs. This might be due to a higher prevalence of certain pests and the states' different farming practices.

Second, the findings confirm that pesticide handling practices are vital for minimizing health and environmental risks. The survey indicated that a significant proportion of farmers followed safety measures like wearing protective gear during pesticide application, a positive finding. However, there is a concerning gap in the safe storage and handling of pesticides, highlighting an area for potential improvement through training and education. To enhance agricultural practices, there is a need to strike a balance between effective pest and weed management and the associated costs. Training and education programs could help farmers make informed decisions about the use of agrochemicals.

Third, there is low awareness of the existence of the PBR cowpea variety, although those informed exhibit a willingness to adopt it, indicating the potential for improving agricultural practices and increasing productivity. This low awareness is understandable, considering that the states and local communities were purposively selected to take advantage of the low preexisting knowledge of PBR

in these two states, to make it feasible for implementing the RCT. This in turn may be explained by the distance of the two states from Nigeria's north-central region (Kano state), where much of the PBR variety development and publicity activities have taken place. Notably, farmers' preference for the cowpea varieties, such as the locally termed "white variety," that align with the characteristics of the new PBR variety, hint at an existing market fit given the similarities in color and taste.

Fourth, the baseline survey enables the IE to adequately account for gendered aspects of cowpea production. By examining the characteristics of the survey's households in both states, the study found that household heads and plot managers were primarily male. This gender disparity is a common feature in many rural Nigerian communities, reflecting broader gender dynamics within society. The distribution of primary sources of income among household heads was another essential aspect of the study. Agriculture remains the predominant source of income in both states, with nearly 90 percent of households in Adamawa and more than 88 percent in Kwara reporting agriculture as their primary occupation. This heavy reliance on agriculture underscores the significance of the sector in rural livelihoods and the need for sustainable agricultural practices and support.

Fifth, the baseline survey also identifies linkages between the self-reported health outcomes of households and cowpea production. In terms of health status, individuals involved in cowpea production self-reported symptoms, such as fever, headaches, and joint pain, which may have been linked to factors like pesticide use, exposure to pests, and overall living conditions. The data showed that these symptoms had a significant impact on individuals' ability to work and incurred medical expenses. This underscored the potential benefits of reducing pesticide use and application (Ahmed et al. 2019; Kouser, Spielman, and Qaim 2019).

A sixth major finding is that the IE is likely to have external validity, allowing the findings to be applied generally to different types of states in Nigeria. The detailed comparative analysis between Adamawa and Kwara reveals nuanced differences in agricultural practices, challenges, and socioeconomic conditions. While Kwara seems more commercially oriented with higher production levels and better infrastructure, Adamawa presents opportunities for improving safety practices and addressing food insecurity. Both states would benefit from targeted interventions addressing their unique local needs. The findings regarding access to electricity as a source of lighting were particularly striking. In Kwara, more than 63 percent of households reported electricity as their source of lighting, while in Adamawa, this figure was just over 13 percent. Access to electricity is essential not only for household activities but also for agricultural operations and income-generating activities. This stark contrast highlighted the regional disparities in access to basic infrastructure, which can have implications for living standards, productivity, and overall quality of life.

Furthermore, land acquisition processes for agricultural purposes differed significantly between Adamawa and Kwara. Inheritance was the primary method in both states, but Kwara had a higher percentage of land rented for agricultural purposes. These variations in land acquisition methods reflect local traditions, availability of land, and economic conditions and can influence land tenure systems, land use patterns, and long-term sustainability of agriculture. Furthermore, the study highlighted that most farmers in both states rely on manual tools for their agricultural practices, indicating limited access to modern agricultural machinery and equipment.

Plot characteristics, soil types, and flood depths also differed between the two states. Notably, the average plot size per household in Kwara was considerably larger than in Adamawa, suggesting differences in land availability and farm management practices. The type of soil and flood depths could affect crop choices, irrigation, and resilience to climate-related challenges (Amare and Balana 2023). Regarding crop production, cowpea is a significant crop in both states. The data on labor use in cowpea production underscores the importance of both hired labor and household labor. The allocation of labor varies depending on tasks and gender roles. Land preparation was predominantly done by men, while women played a crucial role in planting and harvesting. Labor allocation is a key factor in achieving efficient and productive farming practices.

Last, the study also provided insights into the marketing of cowpea, with a focus on the main buyers, sales locations, and transportation methods. In both states, wholesalers were significant buyers because of factors like immediate payment, high/fair prices, and bulk purchases. Marketing practices were influenced by regional factors, including proximity to markets and the availability of resources. Supporting farmers with improved marketing practices, access to markets, and transportation options could positively impact their income and livelihoods. Food security is a complex issue, and the study revealed variations between Adamawa and Kwara. While both states face some level of food insecurity, Kwara generally exhibited better food security outcomes. The reasons for food insecurity differed between the two states, with factors like limited resources, crop pests, lack of farm inputs, and high food prices contributing to food insecurity.

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