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Plant Protection Products Use and Regulatory Compliance in the Nigerian Cowpea (Vigna Unguiculata) Value Chain: Prospects for Lifting the EU Ban

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Abstract

Purpose: This study aims to identify the plant protection products (PPPs) currently used by stakeholders across the Nigerian cowpea value chain and assess how these practices relate to the ongoing export ban.

Methodology: Structured questionnaire consisting of open-ended and closed-ended questions was used to deduce the prevailing factors that are potential impediments to the adoption of the Integrated Pest Management strategy and GAP in ten states identified to be the highest cultivators of cowpea in Nigeria. The data obtained were analyzed using cross-tabulation with Chi-Square tests and Cramer's V to examine association between certain factors and pesticide use.

Findings: Results showed significant associations for decision factors ($X^2(7) = 55.0$, $p < 0.001$, $V = 0.46$) and source of information ($X^2(3) = 12.1$, $p = 0.007$, $V = 0.22$), while farm size showed no significant relationship. Overall, findings suggest effective but inefficient influence of relevant regulatory authorities on the adoption of integrated pest management (IPM), while reliance on conventional pesticides was observed to be significantly influenced by farmers and pesticide vendors due to the availability and effectiveness of conventional pesticides.

Unique Contribution Theory, Policy and Practice: The outcome of the survey identified gaps in the availability and effectiveness of alternatives to hazardous Plant Protection Products (PPPs) and substantiates the need to engage in prospective research that utilizes optimized and sustainable techniques in valorizing potential bioresources into safer and equally effective pesticides; a feasible approach to facilitating the lifting of the current ban.

Keywords: *Cowpea, Biopesticide, Plant Protection Products, Integrated Pest Management, Good Agricultural Practices, Food Safety, Food Security.*

1. INTRODUCTION

Cowpea is a staple grain legume of African origin, commonly known as black-pea or beans in most parts of the world (Ilesanmi & Gungula, 2010; Jha, 2024) but has many native names in Nigeria; ewa (Yoruba), agwa (igbo) waakee (hausa), achi (igede), enje (Idoma) etc. It is cultivated in the tropics and subtropics for both human and animal consumption (Hassan et al., 2018; Omoigui et al., 2020). Due to its ability to withstand drought and a variety of weather conditions, cowpea thrives in different geographical locations and soils (Ilesanmi & Gungula 2016). It is an annually cultivated plant (herb) with a hairy stem and smooth, dark green, alternate and trifoliate leaves of sizes ranging from 2.5 -12.5 cm. Cowpea flowers possess a natural advantage of self-pollinating (Aveling 1999).

Though cowpea is densely cultivated in sub-Saharan Africa, its annual yield peaks in the dry savanna region of Nigeria, where it is usually planted between mid-June to late August, depending on commencement and establishment of rainfall, and harvested within 60 – 75 days after planting, depending on the variety, mono/ intercropping and agroecological zone where it is cultivated (Omoigui et al., 2020).

Cowpea is a staple source of protein in many Nigerian households, consisting of about 25% protein, carbohydrates, minerals, and vitamins. Hence, it is a unique source of multiple nutrients that can be consumed at different stages of its development. Furthermore, cowpea naturally fertilizes the soil with nitrogen (Omoigui et al., 2020), which is why it is mostly co-cultivated with cereal crops.

Kingdom	• Plantae
Division	• Magnoliophyta
Class	• Magnoliopsida
Order	• Febales
Family	• Febaceae
Sub-family	• Faboideae
Tribe	• Phaseoleae
Sub-tribe	• Phaseolinae
Genus	• Vigna
Section	• Catiang
Specie	• Unguiculata

Source: Haseeba et al., 2024

Figure 1 Taxonomy of Cowpea

1.1 Cowpea Cultivation Index in Nigeria

Nigeria has historically been the highest producer of cowpea, with up to 3.63 million metric tons of cowpea over 4.7 million hectares of land in 2021 (FAOSTAT, 2023). This is the closest to the all-time high yield recorded in 2012 (Nwagboso et al., 2024). Yobe, Taraba, Adamawa, Gombe, and Kwara are the highest cultivators of cowpea, followed by Niger, Benue, Kogi, Kaduna, Bauchi, and Jigawa states, and Abuja, while Kano, Sokoto, and Borno States are the largest commercial hubs of cowpea in Nigeria (NAERLS, 2021; Nwagboso et al., 2024). All these states use conventional pesticides as the first line of pest control (Hassan et al., 2018).

1.2 Pest Management Methods and Hazards of PPP

Pests are undesirable organisms that thrive on and cause injury to a host (plant, animal, and human). Pests are of different kinds, such as weeds (plant), insects, pathogens, mollusks, animals (birds, fish), etc. A variety of methods are applicable in the control of pests depending on the type of pest. While pesticide is defined by FAO as any substance or mixture of substances intended for preventing, destroying or controlling any pest including vectors of human and animal disease, unwanted species of plants or animals causing harm during or otherwise interfering with, the production, processing, transport, storage and marketing of food, agricultural commodities, wood and wood products or animal feedstuff, or which may be administered to animals for the control of insects, arachnids, or other pests in or on their bodies. (FAO 1986)

PPPs are broadly classified into natural control and applied control. Natural control refers to certain natural occurrences like wind, temperature, rainfall, topographic features etc., that makes it unconducive for pests to thrive on a host. However, if natural control fails to effectively manage the infestation or destructive activities of the pests, then the applied control is activated (NPAC Core Manual, 2014). Applied controls of pests are classified as biological, chemical, cultural, genetic, mechanical/physical and regulatory controls (NPAC Core Manual, 2014). An integration of the applied pest control methods is known as IPM. Currently in Nigeria, only one method of applied controls (chemical control), otherwise known as conventional pesticide, is predominantly utilized in pest mitigation (Hassan et al., 2018)

The World Health Organization (WHO), in collaboration with the United Nations Environment Program (UNEP), reported the mortality rate of conventional pesticide poisoning to be over 200,000, while injuries caused by inorganic pesticides were estimated to be over 3 million cases (WHO and UNEP, 1990).

Both biopesticides (biochemicals) and conventional pesticides possess a dose-dependent effect on targeted pests, non-targeted organisms, humans, animals, and the environment. However, the safety index (LD50 or LC50) and specificity of biopesticides have a significantly milder impact on human health and the environment compared to conventional pesticides (Ayilara et al., 2023; Joseph Otorkpa et al., 2024). Conventional pesticides are highly poisonous in small doses and are

non-specific to target pests due to their broad spectrum of action. The characteristic hazard of conventional pesticides on the environment and biodiversity is attributed to their persistence in the soil, slow degradation, and infiltration into water bodies, atmosphere, and the food chain (plants and animals) (Ayilara et al., 2023). Pesticides can be absorbed into the body through either one or more of these three major routes: inhalation, contact with skin or eye, and oral ingestion; hence a complete protection of all access routes is required during handling/ reconstitution and application of conventional pesticides (EU PE 653.622, 2021; NPAC Core Manual, 2014). Pesticide poisoning may vary in manifestation, with adverse effects ranging from mild to fatal. The various classes of PPPs and their side effects are listed in Table 1.

Table 1. PPPs and reported associated Side Effects

Chemical Class	Summary of Reported Adverse Effects
Organochlorines	Neurological: Headache, nausea, vomiting, incoordination, dizziness, tremors, convulsions, coma, Endocrine disruption, Carcinogenic
Organophosphates	Cholinergic Overstimulation: Salivation, lacrimation, urination, defecation, gastric cramps, emesis
Carbamates	Neurological: Unresponsiveness, muscle fasciculations, pinpoint pupils, diaphoresis Respiratory distress Cardiovascular complications Respiratory: Difficulty breathing, respiratory paralysis
Pyrethroids	Neurological: Muscle weakness, twitching, seizures, coma Cardiovascular complications Renal dysfunction Neurological: Headache, nausea, vomiting, dizziness, muscle fasciculations, convulsions Dermatological: Skin itching, burning Respiratory distress
Organosulfur	Hepatic: Liver damage, Renal dysfunction, Dermatological: Skin lesions, Respiratory: Difficulty breathing, pulmonary complications
Botanicals	Neurological: Loss of consciousness, seizures, Respiratory distress, Cardiac complications
Biopesticides	Generally, low toxicity rates of rare cases of poisoning may include neurological, respiratory, dermatological, and cardiac effects

Source: (Joseph Otorkpa et al., 2024)

1.3 Antecedents of Integrated Pest Management in Nigeria

Integrated Pest Management (IPM) encompasses all available pest control techniques and other measures that discourage the development of pest populations while minimizing risks to human health and the environment. (WHO/FAO 2023) IPM employs strategic structures to strike a balance between food security and food safety while simultaneously preserving biodiversity and

the ecosystem. IPM tools or strategies include biological, chemical, natural and biologically engineered products for pest control (Crop Life Intr., 2014) and have gained compliance from farmers, aggregators, storekeepers, exporters, regulatory authorities and other stakeholders in the agricultural sector globally as a measure to mitigate multifaceted negative impacts of hazardous chemicals or conventional pesticides on the ecosystem, biodiversity, agri-business and human health (Crop Life Intr., 2014). However, there are certain drawbacks or limitations to the adoption of these measures observed in the cowpea value chain in Nigeria. Despite being the highest producer of cowpea in the world with over 3.6 million ton yield in 2021,(Nwagboso et al., 2024) the probability of being equivalently positioned in the international market is low due to reports of non-compliance with EU's phytosanitary regulation on MRL of ≤0.01 mg/kg as opposed to values ranging from 0.03 mg/kg to 4.6 mg/kg detected on cowpea samples intercepted in the EU in 2013 (Hassan et al., 2018).

1.4 Current Trends in Global Food Regulations

International regulations and corresponding disciplinary actions like bans, suspensions and queries are implemented by world authorities on agriculture, health, and trade, such as IPPC & NPPOs, WTO, WHO, EFSA, FAO, OIE, Codex Alimentarius etc (IPPC Ukraine, 2013) to preserve health, biodiversity, ecosystem and facilitate global food safety and food security. Following the prospective negative impacts of hazardous pesticides on human health and the environment, The European Union Commission on June 22nd, 2022, submitted a proposal for a Sustainable Use of Plant Protection Product (SUR) with the goal of reducing pesticide application by 50% in accordance with EU's green deal fork to farm strategy (EU SUR, 2022). Even though the commission withdrew the SUR application in February 2024 after a few deliberations, (EU SUR, 2024) the EU still upholds its standards on food regulations.

1.5 Global GAP Guidelines on Grains

Good agricultural practices (GAP) intended for the safety and wellbeing of nature and life, encapsulate a wide range of standards spanned across all segments of agricultural practices. In the GAP guidelines for the cultivation of grains, farm management, food safety, worker safety, environmental conservation, and protection of human rights are considered with regards to cultivation management, specie management, management resources, human resources, risk management, overall production structure and overall management structure. GAP is a wholistic approach of ensuring safety, traceability, and accountability in agriculture (GAP Guideline MAFF Japan, 2022). However, in an era of a rapidly growing global population when even the developed countries are striving to achieve food security across different value chains, (Nat Commun 15, 222, 2024) securing a beachhead for the adoption of GAP in Nigeria is still a challenging situation to manage. Inadequate educational exposure among stakeholders is one of the prevailing reasons limiting GAP in Nigeria (Hassan et al., 2018). Moreover, the indiscriminate use of conventional pesticides saves harvest losses worth four times the worth of money spent on pesticides (Hassan

et al., 2018), hence stakeholders rather than striking a balance between food safety and food security, tend to prioritize food security and return on investment with minimal food safety measures put into consideration. The adoption of GAP is subjectively perceived and processed based on the feasibility of sustainability determined by several factors that cannot be fully understood without directly engaging the relevant stakeholders.

1.6 Rationale for the Study

This study explores stakeholders' perception, practices, and challenges in cowpea cultivation and storage in Nigeria, focusing on pesticide use, IPM adoption, and government involvement. Findings aim to identify hazards, barriers, and compliance gaps, thereby justifying the need for further corroboratory studies; cowpea sampling and analysis to identify predominant PPPs used within the population. Moreover, this study precedes a prospective study which focuses on the formulation and production of safer alternatives to conventional pesticides using nanotechnology, hence facilitating the prospects for lifting the EU ban on Nigerian cowpea.

2. MATERIALS AND METHODS

2.1 Study Design

This study employed a cross-sectional design to investigate the choices and methods of application of plant protection products among relevant stakeholders involved in the value chain of cowpea in Nigeria. The survey was conducted from 10th July 2024 to 11th August 2024. A combination of structured questionnaires and voice recordings was used to collect quantitative and qualitative data.

2.2 Participants and Sampling Locations

The participants were selected using non-probability purposive sampling method based on their involvement in the value chain of the crop of interest (cowpea). The survey locations were also purposively selected based on states reported to be the highest producers of cowpea (Nwagboso et al., 2024).

2.3 Data Collection Instruments

Questionnaires:

- Qualitative and quantitative data were obtained by utilizing questionnaires structured to identify certain factors that are potential impediments or catalysts to the adoption of food safety measures like IPM, adherence to MRL, GAP, and government interventions.
- The questionnaires consisted of closed-ended and open-ended questions and were pre-tested with the identified contact person/ facilitator from each of the locations visited to ensure reliability and clarity.

Procedure

Data collection was conducted in three phases:

- Development: the questions were composed based on careful study of existing reports and data on the case study and consultation of experts in the field of study. Afterwards, an ethical clearance was secured for the study.
- Planning: extensive planning was done by a select team of experts in different geographical locations in Nigeria through online and onsite meetings. The topics discussed includes but not limited to identification of facilitators or contact persons residing in the survey locations, findings about possible existence of an association of farmers or cowpea farmers, store keepers, exporters, aggregators and other stakeholders involved in the cowpea value chain facilitation, itinerary, security concerns, health concerns, questionnaire review, need for interpreters considering the numerous ethnic groups and languages in Nigeria, logistics, management of possible unforeseen eventualities, feedback system etc..
- Execution: Prior to data collection, the aim of the survey was explained, and consent of each participant was obtained then, data collection was conducted in person by the team of experts fluent in the languages understood by the participants to ensure clarity.

2.4 Data Management

- Quantitative Data: responses from the questionnaires were coded and input into SPSS (version 30) for analysis.
- Qualitative Data: voice recordings were translated to English language and directly transferred into the questionnaires; the entries were reviewed for accuracy and consistency.

2.5 Data Analysis

The data were analyzed using descriptive statistics and the chi-square test of independence in SPSS. Cross tabulations were generated to examine the association between types of plant protection products (hybrid vs. Conventional pesticides) and key explanatory variables such as factors influencing choices of respondents, size of farmland, type of storage, and sources of information. Rule percentages were computed to allow comparison of method preferences with each category, while Pearson's Chi-square test was applied to assess the statistical significance of associations. Effect sizes were reported using Cramer's V, providing a measure of the strength of the relationship between categorical variables. This approach is appropriate because both the dependent and independent variables are categorical in nature.

2.6 Ethical clearance

Ethical Clearance for this survey was approved and issued by ethics committee of The University of Tsukuba, Japan. Participants were assured of the confidentiality of their responses, and all data were anonymized before analysis.

3. RESULTS

3.1 Sociodemographic Data

Table 2 shows sociodemographic characteristics of respondents. Based on state of origin, all states had 25(9.8%) participation except Taraba, Nasarawa, and Plateau, which had participation of 26(10.2%), 29(11.3%), and 26(10.2%), respectively. Based on age, the highest age group was 25-40 years 115(44.1%), and the least was respondents with <25 years 19(7.4%), the mean age was 40 years. Based on sex, majority of respondents were Male 188(73.4%) compared to Female 68(26.6%) in a Male to Female ratio of (3:1)

Table 2. Sociodemographic characteristics of respondents

Variables	Response	Frequency	Percentage (%)
State of Origin	Benue	25	9.8
	Taraba	26	10.2
	Adamawa	25	9.8
	Yobe	25	9.8
	Kwara	25	9.8
	Borno	25	9.8
	Nasarawa	29	11.3
	Gombe	25	9.8
	Niger	25	9.8
	Plateau	26	10.2
	TOTAL	256	100
Age (Years)	<25	19	7.4
	25-40	113	44.1
	41-55	94	36.7
	>55	30	11.7
	Mean Age	**40.2±13.3**	
Sex	Male	188	73.4
	Female	68	26.6
	M: F Sex ratio	**3:1**	

3.2 Cowpea Production Scale

Table 3 Shows the production Scale of respondents, with respect to agricultural practices. Most farmers were engaged in farming 153(59.8%), followed by a combined practice of farming & Storage 57(22.3%) and least were those who engaged multiple practices (Storage, supply, aggregation) 2(0.8%). With respect to years of consistent involvement, the highest was in those

who engaged for over 20 years 74(28.9%) followed by 11-15 years 58(22.7%) and least was 1-5 years 30(11.7%). Based on the type of crop primarily cultivated, all respondents primarily cultivate cowpea mixed with other crops. Majority 70(27.3%) cultivate three other different crops at least were those who cultivate seven different crops 5(2.0%). The population engaged in farming for different reasons; 44(17.2%) cultivate for the purpose of feeding self and family, 68 (26.6%) sell in the local market, 15 (5.9%) supplied to aggregators and exporters directly, 96 (37.5%) engaged in farming for dual reasons (feeding and selling in the local market), 33 (12.8) engaged in a mix of two or more reasons. The approximate size of farmland or storage facility (store)in the survey population: majority of farmers had a size of farm ranging from 1-5 hectares 143(55.9%), followed by >5 hectares 78(30.5%) while those who had 1- 5 personal stores were 28 (10.9%) and those who rented spaces at a public storage facility (store rent) were 7 (2.7%). Based on farmers status of being registered with the export farmers association of Nigeria, majority 230(89.8%) were not registered, only 14(5.5%) were registered with a government endorsed agricultural association farmers association on Nigeria.

Table 3. Production Scale of respondents

Variables	Response	Frequency	Percentage (%)
Agricultural practices engage	Farming	153	59.8
	Storage	20	7.8
	Supply/Aggregation	24	9.4
	Farming & Storage	57	22.3
	Storage/supply/Aggregation	2	0.8
Years of consistent involvement	1-5	30	11.7
	6-10	55	21.5
	11-15	58	22.7
	16-20	39	15.2
	>20	74	28.9
Type of crops primarily cultivated in addition to Cowpea	One	44	17.2
	Two	49	19.1
	Three	70	27.3
	Four	51	19.9
	Five	27	10.5
	Six	10	3.9
	Seven	5	2.0
Purpose of farming	1. feed myself and family	44	17.2
	2. Sales in local market	68	26.6
	3. Sell to supplier/ aggregator	13	5.1
	4. Exports to international market	-	-
	5. Supply directly to an exporter	2	0.8
	1 & 2	96	37.5
	3&5	3	1.2
	1,2 &5	9	3.5
	1,3 and 4	8	3.1
	Others	13	5.1
Approximate size of farm	1-5 hectares	143	55.9
	>6 hectares	78	30.5
	1-5shop/store	28	10.9
	Store rent	7	2.7
Are you registered with the export farmers association of Nigeria	Yes	14	5.5
	No	230	89.8
	Does not apply to me	12	4.7

3.3 Respondents' Awareness of Biopesticides

Table 4 shows the biopesticide (knowledge and usage) of respondents. Based on Major challenges encountered with beans and/ or maize farming, the single greatest challenge was pest infestation 51(19.9%); however, combination of different challenges was experienced, majorly, (pest infestation, and no support from the government) 52 (20.3%). Majority of the population 138 (53.9%) were not familiar with biopesticides, while 78 (30.5%) use biopesticides in their farming practices. Majority 85(33.2%) revealed they have used neem plant extract, followed by hot pepper 36 (14.1%) and least asserted to have used onion/garlic 7 (2.7%). 62 (24.2%) indicated that they produced their biopesticide themselves, while 36 (14.1%) produced it locally, 26 (10.2%) purchased from IITA or agrochemical vendors at open markets. Frequency of biopesticide application; 71 (27.7%) applied occasionally whenever pest infestation was noticed.

Table 4. Biopesticide (knowledge and usage)

Variables	Response	Freq	Percentage (%)
Major challenge(s) with beans and/ or maize farming	1. Pest infestation	51	19.9
	2. Low return on investment	11	4.3
	3. Low demand	9	3.5
	4. Storage limitation	29	11.3
	5. No support from the government	42	16.4
	6. Soil fertility	22	8.6
	1,2 &6	52	20.3
	All the above	40	15.6
Familiar with concept of biopesticides	Yes	118	46.1
	No	138	53.9
Used biopesticides in your farming practices	Yes	78	30.5
	No	178	69.5
What biopesticides Used before	Neem plant extract	85	33.2
	Hot pepper	36	14.1
	Bioneem	11	4.3
	Biochemical	9	3.5
	Ash/potash	9	3.5
	Onion/garlic	7	2.7
	Not conversant with any	99	38.7
Produce your biopesticide by yourself	Yes	62	24.2
	No	194	75.8
If yes, how u produce	Local	36	14.1
	Market/Agrochemical	26	10.2
	I don't produce any	194	75.8
Frequency of use of biopesticide	Daily	-	-
	Weekly	18	7.0
	Monthly	9	3.5
	Occasionally at notice of infestation	71	27.7
	Never	11	4.3
	Does not apply to me	126	49.2

3.4 Respondents' Reliance Levels on Conventional PPPs

Table 5 shows Conventional pesticide (knowledge and usage). With respect to Source of information, majority through a single source 51(19.9%) get their information from other farmers, followed by pesticides retailers 41(16.0%). A large majority get their information through a combined source (Other farmers & pesticides retailers) 118(46.1%). Least were those who got information from agricultural extension services/magazine 19(3.9%). The majority used it occasionally when pest infestation is noticed 161(62.9%). Precautionary measure before use was

majorly 3 of 5 102(39.8%). The most frequently experienced symptoms after use were (Vomiting/Nausea/dizziness) 62(24.2%), followed by (Headache/back pain/stomach pain) 27(10.5%), and the least was difficulty in breathing and burning sensation 9(3.5%) each. The Safety of storage of pesticide remnant and disposal of empty pesticide containers of pesticide were majorly considered on unsafe with a percentage 0f 234(91.4%) and 221(86.3%) respectively.

Table 5. Conventional pesticide (knowledge and usage)

Variables	Response	Freq	Percentage (%)
Source of information	1. Agricultural extension services	18	7.0
	2. Magazine/Publications	7	2.7
	3. Online forum/Websites	3	1.2
	4. Other farmers	51	19.9
	5. Pesticide retailers	41	16.0
	4 & 5	118	46.1
	1 & 2	19	3.9
	All the above	8	3.1
Frequency of use of pesticide	Weekly	32	12.5
	Monthly	44	17.2
	Occasionally on notice of pest	161	62.9
	Never	16	6.3
	The question does not apply to me	3	1.2
Precaution measure before use	0 of 5	15	5.9
	1 of 5	39	15.2
	2 of 5	79	30.9
	3 of 5	102	39.8
	4 of 5	16	6.3
	5 of 5	5	2.0
Symptoms experienced after use	None	114	44.5
	Vomiting/Nausea/dizziness	62	24.2
	Headache/back pain/stomach pain	27	10.5
	Skin irritation	23	9.0
	Difficulty breathing	9	3.5
	Burning sensation	9	3.5
	Fever	12	4.7
Safety of storage of remnants of pesticide	Safe	22	8.6
	Unsafe	234	91.4
Safety of disposal of empty Containers of pesticide	Safe	34	13.3
	Unsafe	221	86.3

3.5 Relationship between Variables and Respondents' Choices of PPPs

Table 6 shows the perception and attitudes of farmers with respect to factors that influence the choice of PPP. Based on a single choice, effectiveness in pest control 56(21.9%) was the major factor; however, a large portion of the population based their choices on multiple factors (availability, cost & effectiveness in pest control) 46(18.0%). For the relative effectiveness between biopesticides and conventional pesticides, the majority, 140(54.7%), indicated they were not sure; however, 58(22.7%) said biopesticides are less effective, while 44(17.2%) said biopesticides are more effective. When asked about their concerns about using biopesticides in farming practices, the majority, 198(77.3%), said effectiveness is their major concern, followed by availability, 20(7.8%). However, 152(59.4%) believe well-developed biopesticides can contribute to sustainable farming practices in future while 195(76.2%) indicated willingness to invest in biopesticides if modified to be safer and equally effective relative to conventional pesticides in future.

Table 6 Perception and attitudes

Variables	Response	Freq	Percentage (%)
Factors that influence choice	1. Availability	21	8.2
	2. Cost effectiveness	15	5.9
	3. Effectiveness in pest control	56	21.9
	4. Environmental impact	8	3.1
	5. Health concerns self & farm workers	20	7.8
	6. Residual effects on crops	7	2.7
	7. Regulatory compliance	12	4.7
	1, 2, & 3	46	18.0
	All the above	22	8.6
	Question does not apply	49	19
Effectiveness of biopesticides compared to conventional pesticides	More effective	44	17.2
	Equally effective	14	5.5
	Less effective	58	22.7
	Not sure	140	54.7
Concerns of using biopesticides in your farming practices	Toxicity	5	2.0
	Safety	8	3.1
	Availability	20	7.8
	Cost	19	7.4
	Effectiveness	198	77.3
	None	6	2.3
Do use of biopesticides contributes to sustainable farming practices	yes	152	59.4
	No	10	3.9
	Not sure	94	36.7
Willingness to invest in biopesticides if modified to be safer and equally effective	yes	195	76.2
	No	17	6.6
	Maybe	44	17.2

Future Considerations. Improvements or advancements needed in biopesticides to make them more attractive to farmers are listed in Table 7, and the following suggestions were made: awareness 93(36.3%), training and packaging 53(29.7%), effectiveness 52(20.3%), and government support 7(2.7%). Assessment of whether farmers are open to receiving training or educational programs on the proper use of biopesticides revealed that the majority (230, 89.8%) said yes. While 225 (87.9%) wish to expand their farming to a commercial scale.

Table 7. Future Considerations

Variables	Response	Freq	Percentage (%)
Improvements or advancements needed in biopesticides to make them more attractive to farmers (key barriers to wider adoption of biopesticides in agriculture)	Awareness	93	36.3
	Availability	33	12.9
	Cost	18	7.0
	Effectiveness	52	20.3
	Government Support	7	2.7
	Training and Packaging	53	29.7
Open to receiving training or educational programs on the proper use of biopesticides?	Yes	230	89.8
	No	19	7.4
	Maybe	7	2.7
Like to expand your farming to a commercial scale	Respondent is a commercial farmer	25	9.8
	Yes	225	87.9
	No	6	2.3

Table 8 shows the prevailing pest control methods employed by farmers and storers of cowpea in Nigeria. Overall, the chi-square test conducted to examine the relationship between variables and pest control methods (conventional pesticides and hybrid) revealed that source of information and 7 factors that influence choice of PPPs were both significant at P values = 0.001 while sizes of farmland were not statistically significant among the population [X^2(df, N = 256)] at (p = 0.201) when significance level was set at p< 0.005.

Among those who used hybrid methods 15 (75.0%) did so to avert health risks while 45 (80.4%) of those who relied solely on conventional pesticides cited effectiveness. For those considering multiple factors (availability, cost-effectiveness and pest-control efficacy), 34 (73.9%) preferred conventional pesticides compared to 12 (26.1%) who used hybrid.

Regarding source of information, 6 (85.7%) of magazine/publication users chose conventional pesticides, while only 1(14.3%) opted for hybrid. Farmers and pesticide retailers influenced 95 (80.5%) to use conventional pesticides, compared to 23 (19.5%) who chose hybrid. Overall, 178 (69.5%) used conventional pesticides exclusively while 78 (30.5%) adopted hybrid method.

Table 8. Distribution of PPP type by key predictors

Predictor (Category)	Hybrid (%)	Conventional (%)	Total (n)	X^2(df)	p-value
Factor (Reason for choice)					
Affordability	33.3	66.7	33	55.0 (7)	<0.001
Availability	15.0	85.0	40		
Effectiveness	20.3	79.7	74		
Environmental impact	36.4	63.6	11		
Health concerns	73.9	26.1	23		
Regulatory compliance	73.3	26.7	15		
Residual effects on crops	50.0	50.0	10		
Not applicable	10.0	90.0	50		
Farm size/storage type					
≤ 5 hectares	34.3	65.7	143	2.97 (2)	0.226
> 5 hectares	28.2	71.8	78		
Other (wholesale/retail storage)	20.0	80.0	35		
Source of information					
Agric. extension services	55.6	44.4	18	12.1 (3)	0.007
Farmers	30.0	70.0	110		
Pesticide vendors	22.0	78.0	100		
Others (magazines, online)	46.4	53.6	28		

Chi-Square tests (X2, df, p) and effect size (Cramer's V) are reported once per block of variables (Decision factors, farm size, source of information). They evaluate the overall association between the block and choice of PPP. Percentages are row-based (within each category). Statistical significance was set at $p < 0.05$.

Table 7 shows in case squared tests of independence conducted to examine the relationship between factors influencing pest control choice and type of plant protection products (hybrid vs. conventional). Table 7b further detailed that the association was statistically significant X2(7) = 55.00, N = 256, $p < 0.001$. The effect size was strong (Cramer's V = 0.464). Farmers citing health concerns (73.3%) were much more likely to use hybrid methods, whereas those prioritizing availability (85.0%), effectiveness (79.7%) and cases where the question was not applicable (90%) favored conventional pesticides

Statistics of farm size/ type of storage investment. Details on table 7b show that X2(2, N=256) = 2.972, p= 0.226 is not significant. Effect size: Cramer's V = 0.108 (weak and not significant). Farm size/ type of storage investment did not significantly influence whether farmers chose hybrid or conventional PPP.

Also, the relationship between sources of information and type of PPPs used by the respondents suggests a moderate but significant relationship emerged $X^2(3, N = 256) = 12.110$, $p = 0.007$, Cramer's $V = 0.218$. Farmers relying on agricultural extension services showed a greater tendency to use hybrid plant protection products (55.6%), while those guided by pesticide vendors (78.0% conventional) or fellow farmers (70.0% conventional) leaned toward conventional PPPs. This highlights the critical role of extension services in promoting hybrid (IPM) adoption, in contrast to vendor-driven recommendations which sustain conventional use.

Table 9. Chi-Square tests and effect sizes for predictors of PPP type

Variable Pair (Independent × Dependent)	χ^2 (df, N)	p-value	Cramer's V	Strength	Significance	Interpretation
Factor × Type of PPP	55.001 (7, 256)	< .001	.464	Strong	***	Motivational factors strongly predict Hybrid adoption
Farm Size/Storage × Type of PPP	2.972 (2, 256)	.226	.108	Weak (ns)	ns	No significant effect of farm size/storage
Source of Information × Type of PPP	12.110 (3, 256)	.007	.218	Moderate	**	Extension services favor Hybrid, vendors/farmers sustain Conventional

4. DISCUSSION

4.1 Sociodemographic Data

The demographic data analysis in reveals a total of 256 participants were engaged in the survey, the ratio of male to female respondents was 3:1, and a higher percentage of the population was middle-aged men between 25 – 55 years old. According to the data generated, women engaged more in the commercial and storage aspects of the value chain, while men engaged more in active farming.

The choice of survey location was determined by existing data of states with the highest cowpea cultivation record in 2021 (NAERLS, 2021). Cowpea cultivation and storage is predominantly done in the northern region of Nigeria due to its vast and arable land mass. Moreover, agriculture is a major source of livelihood in Nigeria, especially in the rural areas in the Northern region (Statista, 2024).

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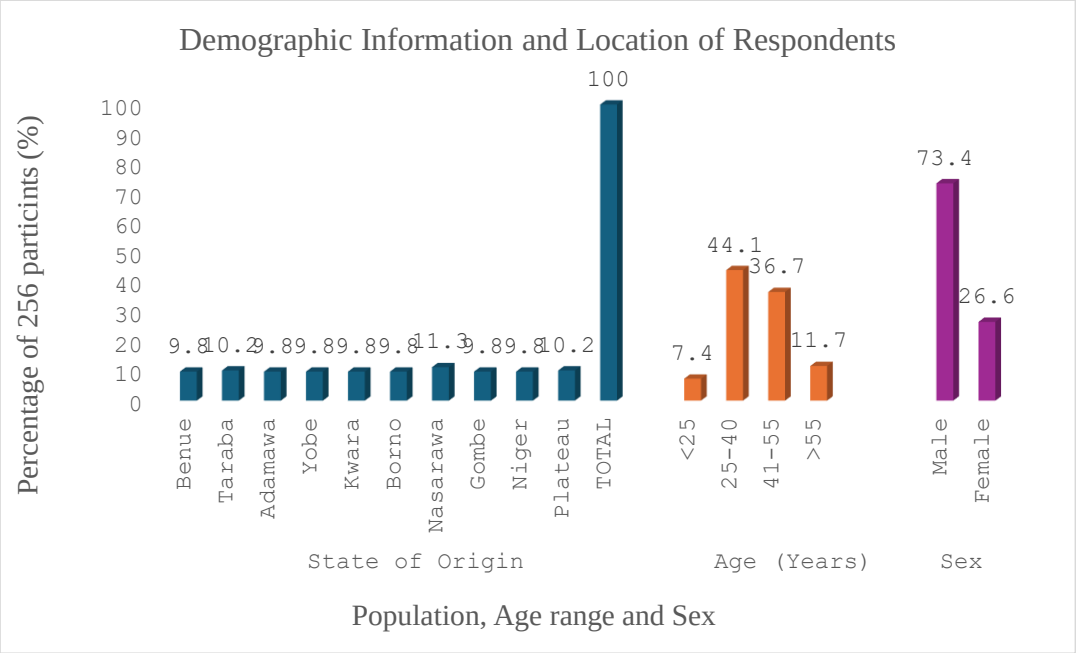
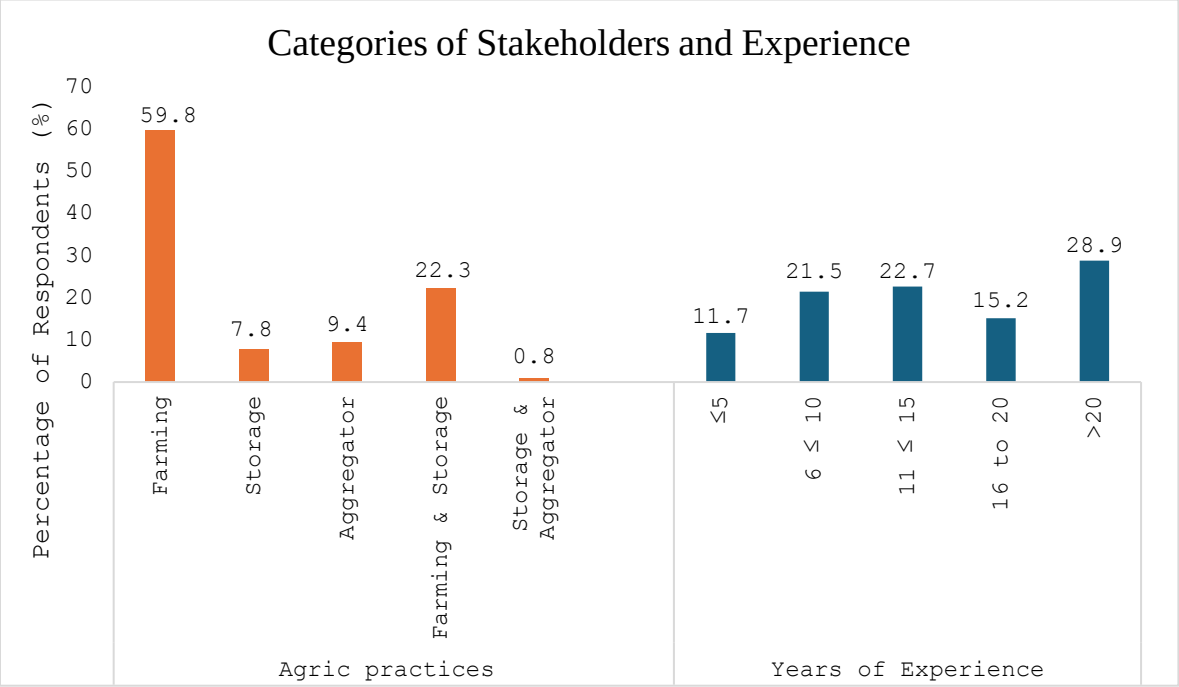


Source: Primary data 2024.

Figure 2. Demographic Data

This data suggests that farming starts at an early age (< 15 years) among the population, with most of the farmers having over 10 years of experience in farming. Farmers are the largest stakeholders in the cowpea value chain, with up to 59.8% of the survey population. majority of farmers have engaged in active cultivation of cowpea and other crops for over 20 years. Also, 22.8% of the population engages in farming and storage of cowpea. The aggregators are stakeholders who purchase farm produce directly from farmers during/ after harvest for two main reasons: supply in bulk to exporters or store in bulk until demand is high. Hence the aggregators bridge the gap between farmers who are mostly settled in the rural areas and exporters who carry out their businesses close to the ports (air, sea or land borders). Aggregators, often called suppliers, are the key technical determinants of demand and supply of cowpea in Nigeria. Due to the minute ratio of aggregators to farmers (6:1) depicted in fig.3., it can be inferred that one aggregator services numerous farmers hence the regulatory authorities and associated food laws enforcement agencies can collaborate with the aggregators to effectively facilitate food safety and traceability of agricultural commodities by initiating transactions with the farmers based on terms and conditions in accordance with IPM and GAP standards. On the other hand, if aggregators are not knowledgeable on food safety standards, traceability becomes a challenge during HACCP because important parameters like the farm manager and location, plant protection products applied, pest infestations observed, and visible plant diseases may be neglected (Hassan et al., 2018). Inclusive

agricultural development partnership between government regulatory authorities and stakeholders is encouraged for food safety facilitation in the cowpea value chain (NPAC Core Manual, 2014).



Source: primary data 2024.

Figure 3. Category of Stakeholders and Years of Experience in Cowpea Value Chain

4.2 Cowpea Production Scale

In addition to cowpea, farmers and other stakeholders engaged in the production of 2 to 8 other crops for the purpose of feeding and commerce. Nevertheless, farmers, aggregators and storekeepers are the most dominantly accessible stakeholders in the rural areas where the survey was done. This is because the exporters usually manage their businesses in urban settlements while the aggregators play the middle role. The exporters are positioned towards the tail end of the value chain next to the Nigerian Plant Protection Organization (NPPO). Hence exporters take the biggest financial risk in the cowpea value chain as they may incur losses if the consignments fail the domestic or international phytosanitary tests as illustrated on fig. 5. It is therefore imperative that the government involves exporters food safety facilitation through capacity building on phytosanitary measures, this will enable exporters to transact conditionally with aggregators by ensuring that the aggregated consignments conformed to phytosanitary measures or perhaps documentation and labelling was properly done to enable traceability in the event of non-compliance with standards (NPAC Core Manual, 2014).

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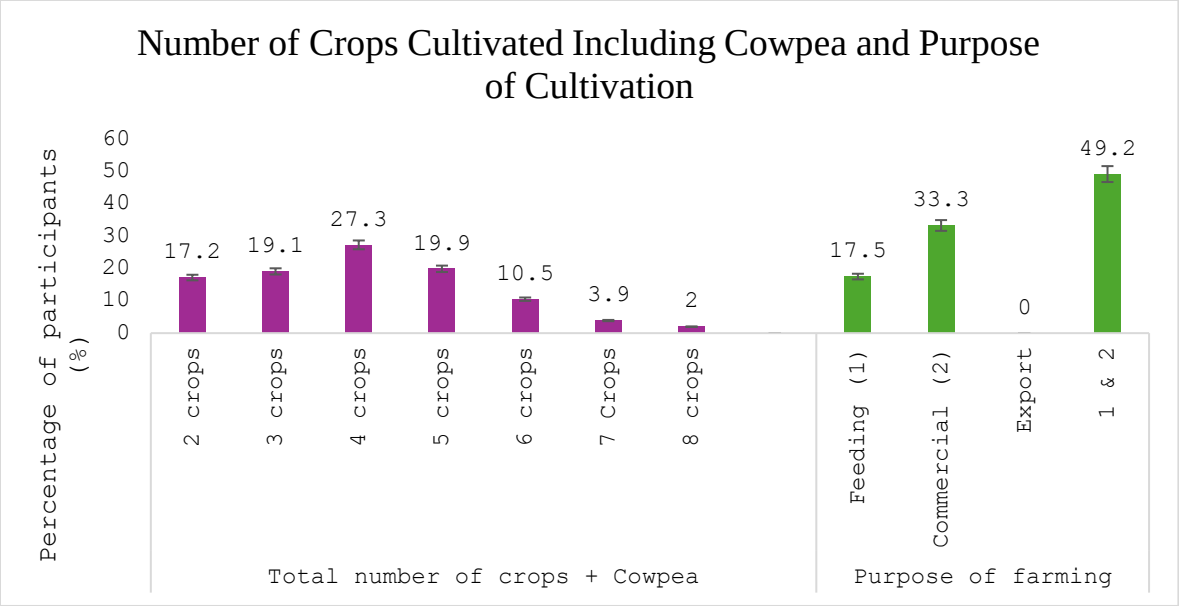
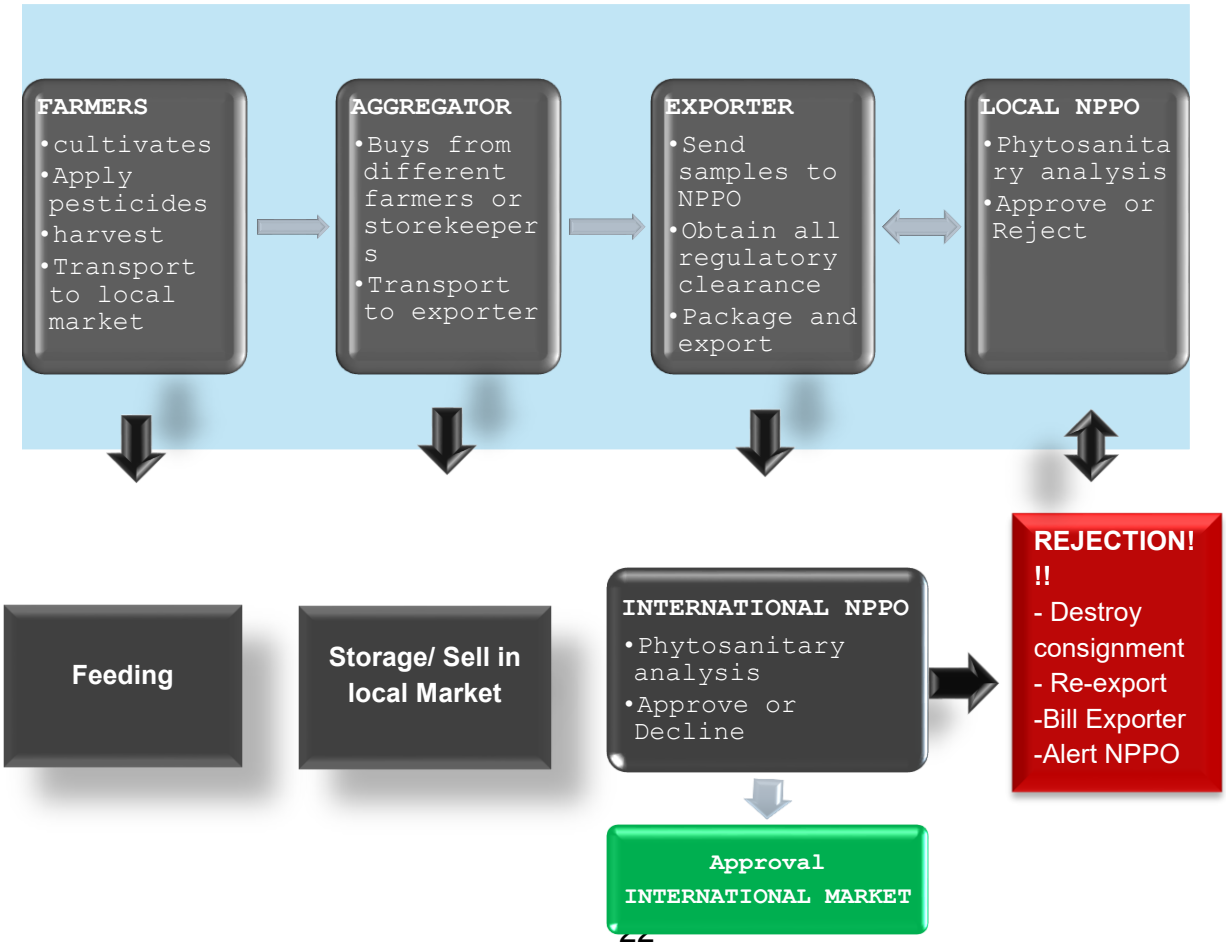


Source: Primary data 2024.

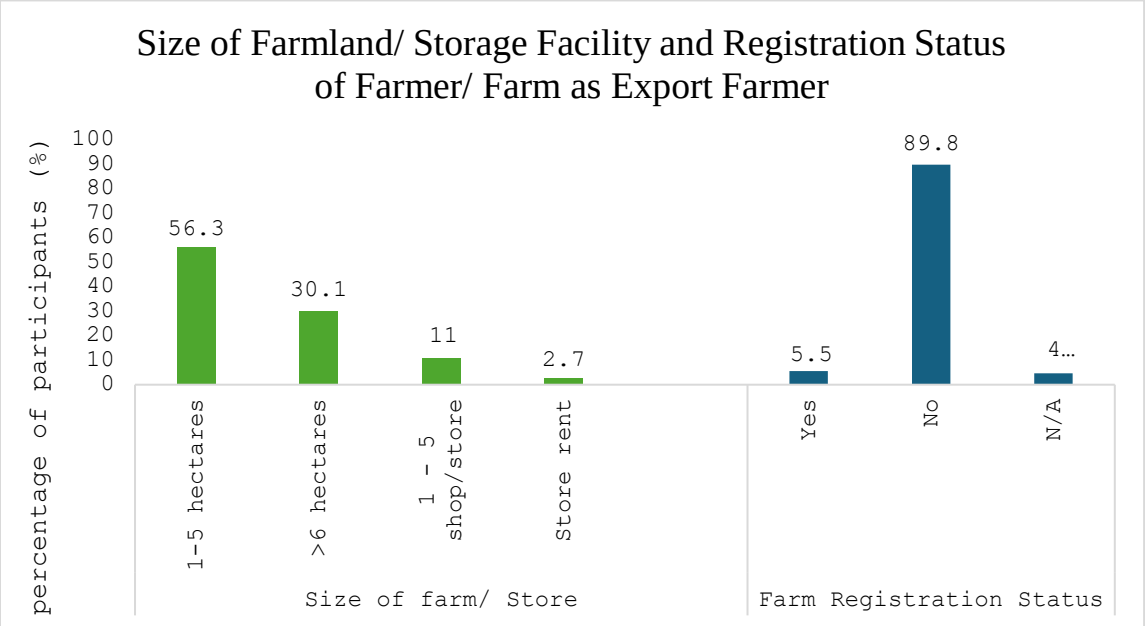
Figure 4. Purpose of Engagement in Cowpea Value Chain and Other Crops



Source: Primary data and IPPC Ukraine 2013.

Figure 5. Cowpea Value Chain

According to responses from the population, almost 90 percent of the farmlands/ farmers are not registered with any association of e.g., Export Farmers Association of Nigeria etc. hence compounding the drawbacks of traceability for the aggregator, exporter and local NPPO. This could be because the population mainly engage in farming for feeding or sales at the local market as illustrated on Fig. 4. Even though farmers wish to increase output, (Fig. 11) very few have the means to rent or acquire such an expanse of land. According to the illustration of most respondents, lands are often owned by or allocated to individual families in rural settlements traditionally based on certain cultural criteria linked to marriage, royalty, gender and community norms. This data explains why a higher percentage of the population falls within the age bracket of 25 – 40 years (Fig. 2) and own smaller pieces of land (5 hectares and below) depicted in fig. 6. Moreover, 25-40 year corresponds with the age bracket of first marriage in Nigeria (Wikipedia, 2025). Also, Fig.3 corroborates Fig. 4 on why majority of the stakeholders are farmers and engage in farming for the purpose of feeding and local small-scale commerce.



Source: Primary data

Figure 6. Scale of engagement and registration status of cowpea farmers/ farms

Fig. 6 gives further insight into the ratio disparity between farmers and aggregators. Also, stakeholders who store cowpea for commercial purpose either have personal storage facilities or rent spaces in the public storage facilities.

4.3 Respondents' Awareness of Biopesticides

The challenges encountered by stakeholders in the cowpea value chain in Nigeria are majorly pest infestation and inadequate government support in ensuring food security and safety. The risk of low return on investment (ROI) and soil fertility are the least indicated challenges. (Fig.7) This suggests that pests are the greatest risk to food security in the Nigerian value chain hence the use of pesticides to address this challenge is very common. Cowpea stakeholders can incur up to 95% losses due to pest infestation, beans weevils (*Callosobruchus maculatus*) being one of the major pests affecting post-harvest storage of cowpea (Ilesanmi & Gungula, 2010)

Figure 8 depicts the ease of accessibility to hazardous pesticides random buyers who may not have the license and expertise to store or use such poisonous chemicals in one of the survey locations in Nigeria.

The National Agency for Food and Drug Administration and Control (NAFDAC) is the regulatory authority that inspects the pesticides production facilities and warehouses, register pesticide products, carry out effective surveillance and continuous monitoring of safe and responsible use of pesticides, oversee the listing of pesticides and agrochemical marketers, inspect pesticides at the ports (point of entry), investigate and ensure compliance with proper handling of pesticides and carrying out awareness among stakeholders (NAFDAC, 2022). The mandate of NAFDAC suggests it is the appropriate authority to curtail the indecent availability of highly poisonous PPPs to uninformed and untrained stakeholders. However, the data generated from the survey locations displays high availability and random access to conventional pesticides. Furthermore, 46.1% of the survey population are aware of IPM but only 7% got such information from regulatory authorities while 93% sourced information on PPPs from unreliable or unverifiable sources. The disparity between the sources of information reflects minimal inclusivity of stakeholders in food safety awareness programs/ training.

According to the data depicted in Fig. 7., conventional pesticides are the most prevalently used PPPs by farmers, aggregators, and storekeepers in cowpea production in Nigeria (Nwagboso et al., 2024).

100% of the survey population uses conventional pesticides among them, 69.5% use only conventional pesticides regularly while 30.5% uses both conventional pesticides often and biopesticides occasionally. However, 46% of the participants are superficially aware of only one class of IPM strategy (botanical biopesticides) which they produce by themselves locally or purchase from pesticides vendors while 53.9% have no idea of any other type of PPPs aside from conventional pesticides. Majority of these stakeholders apply multiple pesticides to ensure that losses are not incurred at harvest (EU PE 653.622, 2021).

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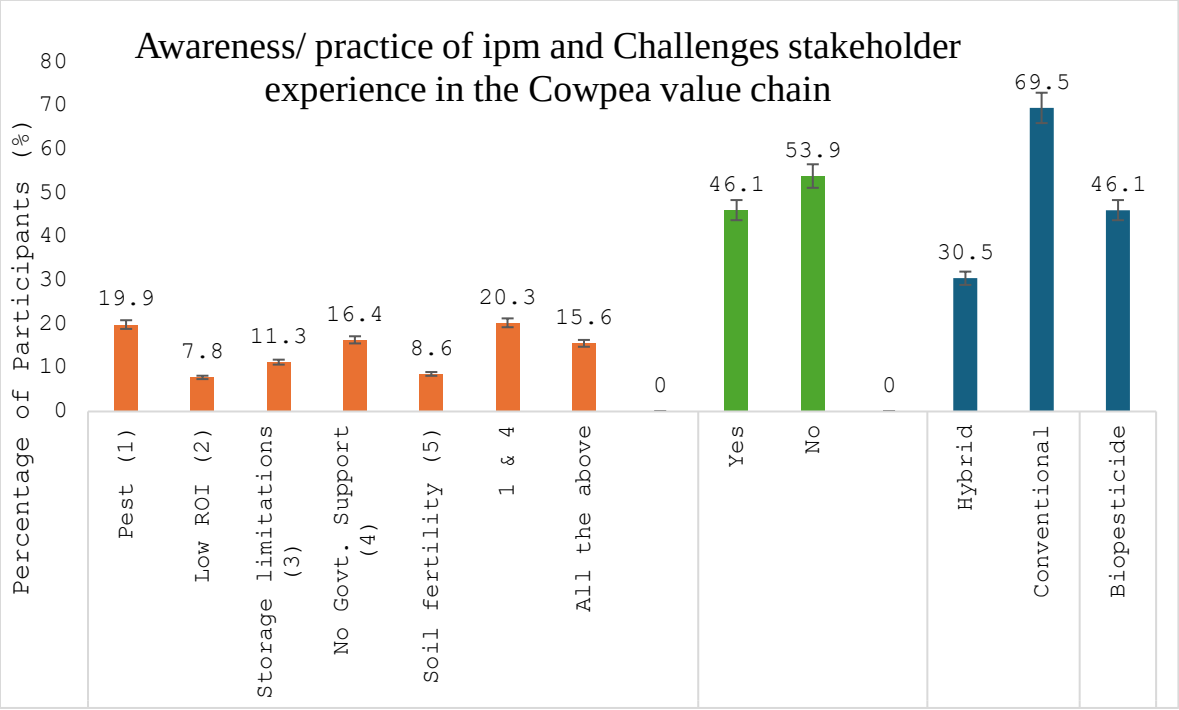
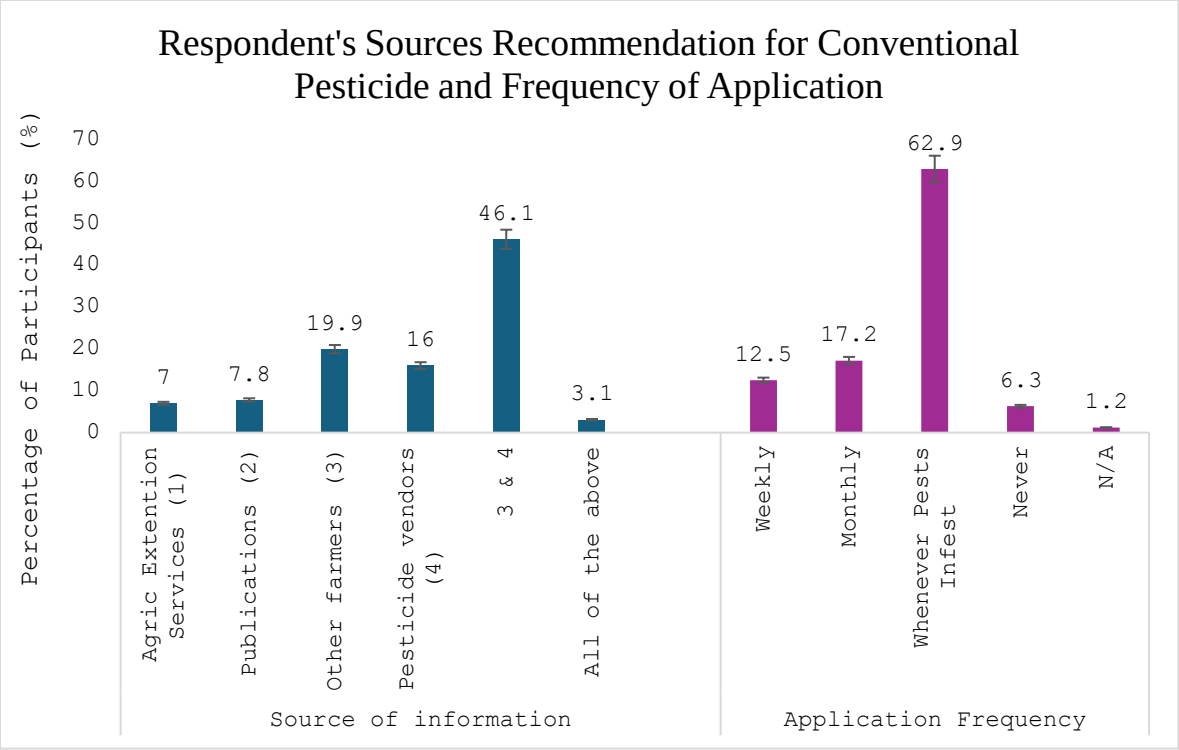


Source: Primary data.

Figure 7. Awareness/ Adoption of IPM Strategy among Stakeholders and Challenges of the Cowpea Value Chain

Source Primary data 2024.

Figure 8. Argo-pesticide Vendors in Jengre Market Plateau State Nigeria



Source: Primary data 2024.

Figure 9. Stakeholders' Source of Information, Use, Storage and Disposal of PPPs

4.4 Respondents' Reliance Levels on Conventional PPPs

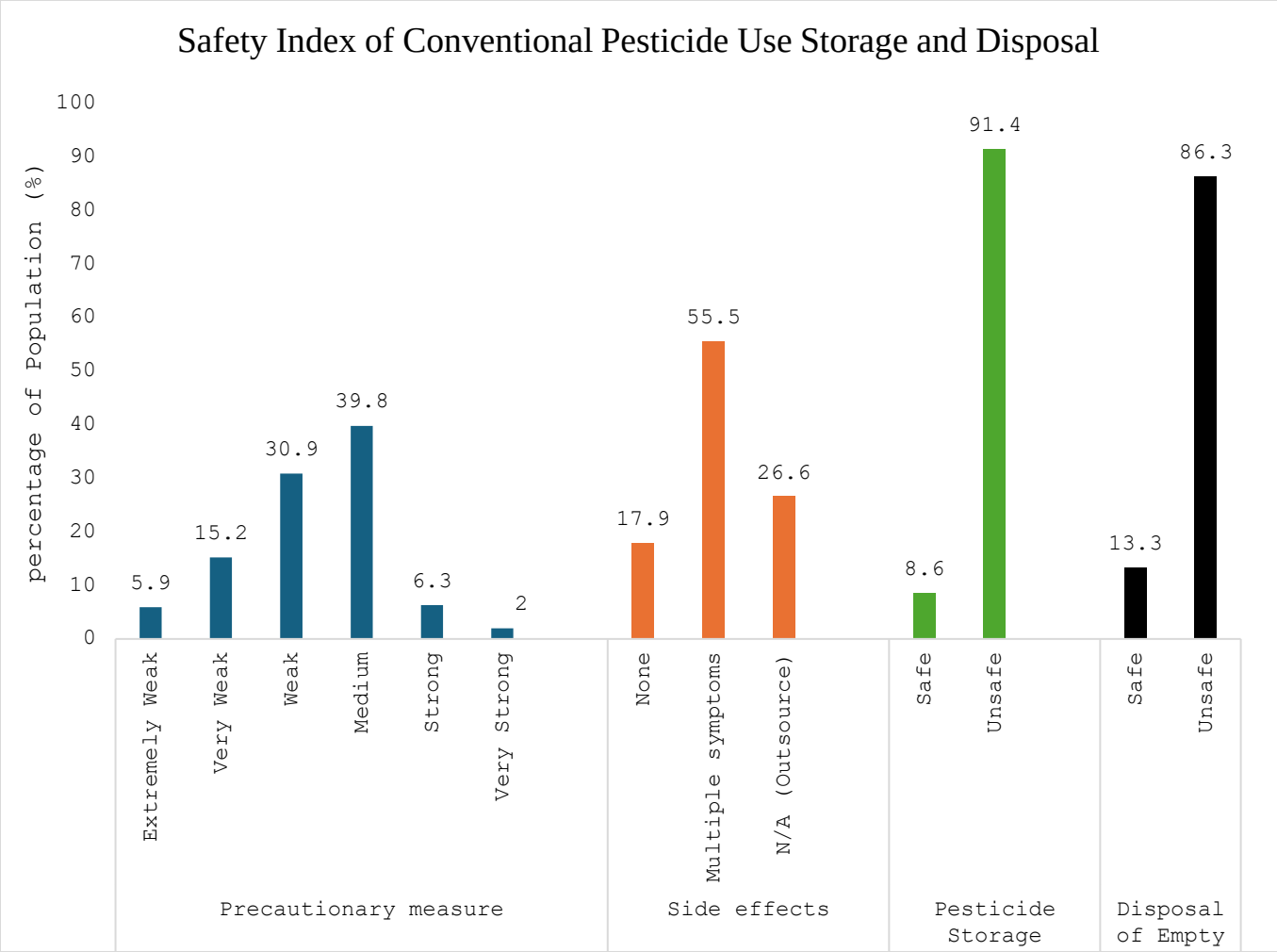
Pesticides, due to high toxicity profile, and intended application on food should be handled by professionals who have undergone the necessary training and passed the prescribed examinations. E.g., in the United States of America, Pesticide Applicator Certification Core examination is one of the criteria mandated by pesticide regulatory agencies to qualify the examinee as a registered technician is who licensed to be a commercial or private applicator in accordance with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (NPAC Core Manual, 2014).

According to the data generated from this survey and shown in Figure 9, 46.1% of the population relies on either farmer, pesticide vendors or both for information regarding the choice, use and disposal of PPPs or emptied containers while only 7% of the population interface with staff(s) of relevant government regulatory authorities who are mandated to provide information and services of PPPs. In Nigeria, different regulatory authorities are mandated to interface with agricultural stakeholders on issues of food security and food safety at different points in the value chain.

The National Agricultural Extension and Liaison Services (NAERLS) are mandated to conduct agricultural performance assessments, build capacity and skills key actors for effective services, package and disseminate improved agricultural innovations among other duties (NAERLS, 2021).

Nigeria Agricultural Quarantine Service (NAQS) is Nigeria's National Plant Protection Organization (NPPO) Nigeria's signatory to the International Plant Protection Convention (IPPC). The NAQS upholds the mandate to prevent the entry and establishment of exotic pests and diseases of agricultural produce/ products (plants/ plant products, animal/ animal products and aquatic resources/aquatic resources products). In the same manner, this prevention extends to consignments that are exported to the international markets. The NAQS also controls the movement of agricultural produce/ products locally across states to prevent cross-infestation of pests and diseases between high and low risk regions. The mandate of the NAQS is structured to ensure food security, food safety and facilitate local and international trade of safe agricultural commodities through sample collections from export consignments, farms, local markets for visual inspection for identification of debris/ pest infestation or detailed standard laboratory analysis for detection of microbial and chemical contaminants (NAQS, 2018). Even though the activities of the NAQS spans across different points of the agricultural commodity value chain, two crucial points of utmost significance to food security are the post-entry quarantine services (first point of contact) for imported agricultural consignments and the last point of contact that confirms compliance with sanitary and phytosanitary measures (SPS) and issues phytosanitary certificate for export consignments (NAQS, 2018).

The data generated suggests that inclusivity of farmers, storekeepers and aggregators in SPS, IPM and GAP needs reinvigoration through a collaborative effort of the relevant regulatory agencies to achieve a common goal of achieving sustainable food security and food safety in accordance with SDG2 by sufficiently extending the scope of awareness programs and trainings to the rural settlements. A sustained collaboration between Nigerian regulatory authorities is inevitable considering the drastically increasing population of Nigeria estimated to be over 230 million in 2025 (Worldometer, 2024). This statistic implies increasing demand for food which further translates to a spike in the incidences of indiscriminate use of available PPPs by stakeholders to avert harvest losses. Also, collaborations can cushion the disparity between the ratio of law enforcement agencies to stakeholders for effective dissemination of information on PPPs use, storage and disposal.



Source: Primary data 2024

Figure 10. Safety Index of Conventional Pesticides Use Among Stakeholders

The precautionary measures that stakeholders observed during pesticide application in field or storage facilities were ranked from 1-6 based on the applicators' ability to protect the eyes, nose, hands, legs and body by wearing protective glasses, nose mask, protective footwear, hand gloves and coverall respectively. The operators who used all five protective kits were ranked very strong, those who used 3 out of 5 were ranked medium while those who used non were ranked extremely weak. (Fig. 11)

Majority of the population (39.8%) observed three out of five precautionary measures while only 2% of the population observed all five precautionary measures.

The disposal of empty pesticide containers after use was broadly categorized as safe or unsafe based on the data generated from the questionnaires. Safe or unsafe disposal of pesticides were

categorized based on compliance or non-compliance with Environmentally Sound Management (ESM) measures (NESREA, 2020). Although safe disposal includes compliance with the disposal instructions on the pesticide label however, majority of the stakeholders who carry out pesticide application are not literate enough to comprehend and follow these instructions, (Nwagboso et al., 2024) hence a sustainable safe method would be an outright destruction of the containers after use to avert attraction for reuse followed by disposal at a central point accessible to the national environmental sanitation services board who routinely collects wastes and sorts them for incineration etc.(PCPB Kenya, 2019). Majority of the respondents either threw empty containers on the farmlands, burned them, washed and reused them or buried them.

Storage of pesticides was likewise categorized as safe and unsafe based on proper isolation of pesticides to a designated area safely locked or kept away from the reach of children and from proximity to food or water (NESREA, 2020; PCPB Kenya, 2019). Majority of the participants stored pesticides in their living rooms or bedrooms while a few kept them in easily accessible locations at their farmhouses.

The adverse symptoms experienced by the respondents who engaged in pesticide application include nausea, vomiting, redness of the eyes, burning sensation in the eyes, itching on skin, headache, dizziness, apnea or breathlessness, backpain, cough, fast heartbeat, burning sensation on the skin which are all symptoms secondary to pesticide poisoning (Joseph Otorkpa et al., 2024). Respondents also indicated experiencing multiple symptoms which corroborates the low safety precautionary index on Fig. 11. Undoubtedly, pesticide aerosols are gaining entrance through multiple administrable routes (nasal, eyes, skin, mouth). The safety index of the general safe use storage and disposal of pesticides among the population can be attributed to inadequate information and guidance provided to the end users (Fig. 9). Moreover, must end users indicated that they applied pesticides as frequently as weekly, monthly or occasionally whenever pests infested the farmlands. Also, the application of multiple pesticides frequently without taking necessary precautionary measures can predispose the applicator to multiple side effects of chronic or acute pesticide poisoning.

Some of the major pesticides used for field and storage pest mitigation by the population are aluminum phosphide (BOM), DD force, sharpshooter, paraforce, gramazole, seven days, sniper, gramosun, gramospark etc. However, majority of the farmers and storekeepers use aluminum phosphide for post-harvest storage by wrapping the tablets in a piece of cloth and inserting deeply into the sac containing cowpea.

4.5 Relationship between Variables and Respondents' Choices of PPPs

The findings from the series of figures 12, 13, and 14 highlight that choices of pest control products used by cowpea producers in the survey regions are informed by the perception of risks of infestation and influence of recommendations from fellow farmers, pesticide vendors, rather than

their scale of operations. The strong effect of decision-making parameters suggests that with a convincing recommendation from reliable sources such as extension service providers, hybrid methods can be adopted by cowpea producers when making choices of PPPs to use on their produce due to a conscious effort to prioritize health concerns and regulatory standards. Conversely, reliance on availability and effectiveness are strong economic factors that predict continuous demand for conventional pesticides due to limited access to potent bioinsecticides in rural areas. The influence of information sources on farmer's choices of hybrid PPPs magnified the need for increased facilitation of IPM and GAP by extension service providers; finding suggests effective but inefficient services provided within survey population. Hence the need for the government and regulatory agencies to augment services in rural areas. Also, the significant influence of conventional pesticide vendors and farmers on respondents' choices of conventional PPPs due to effectiveness in pest control further corroborates the need for safer, equally potent and sustainable organic PPP alternatives through adequate investment in research and development of bioresources naturally and abundantly available in the country.

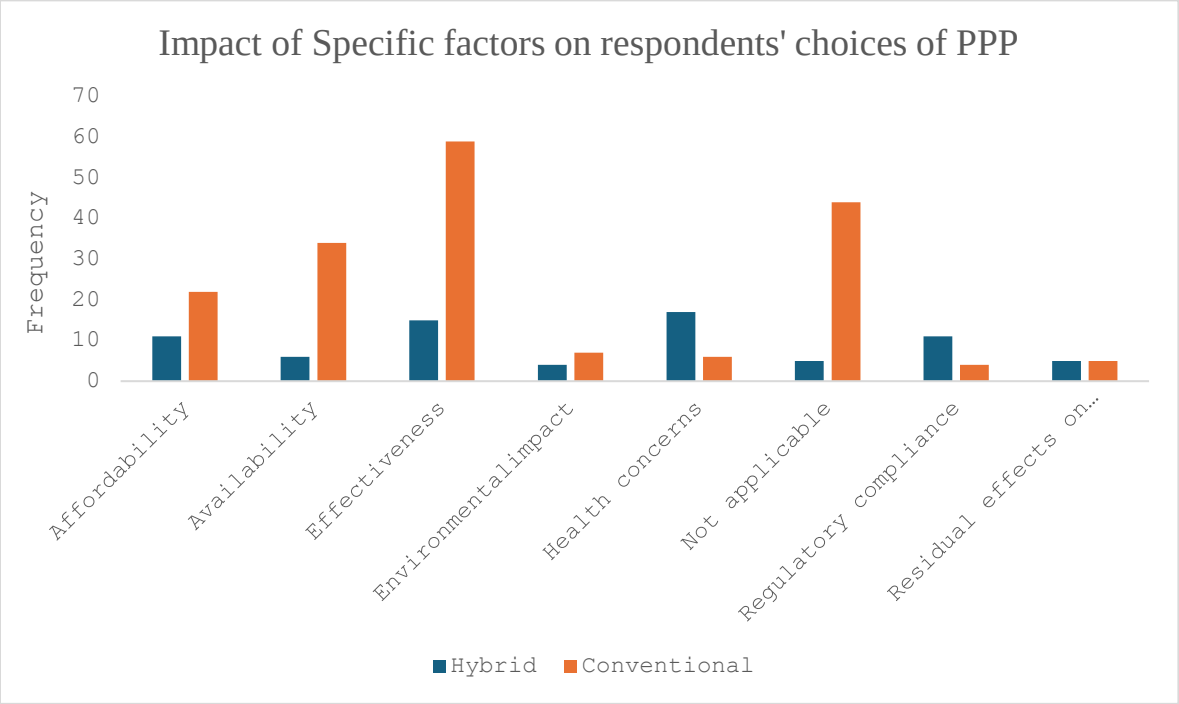


Figure 12. Distribution of the influence of specific factors on the choices of PPP

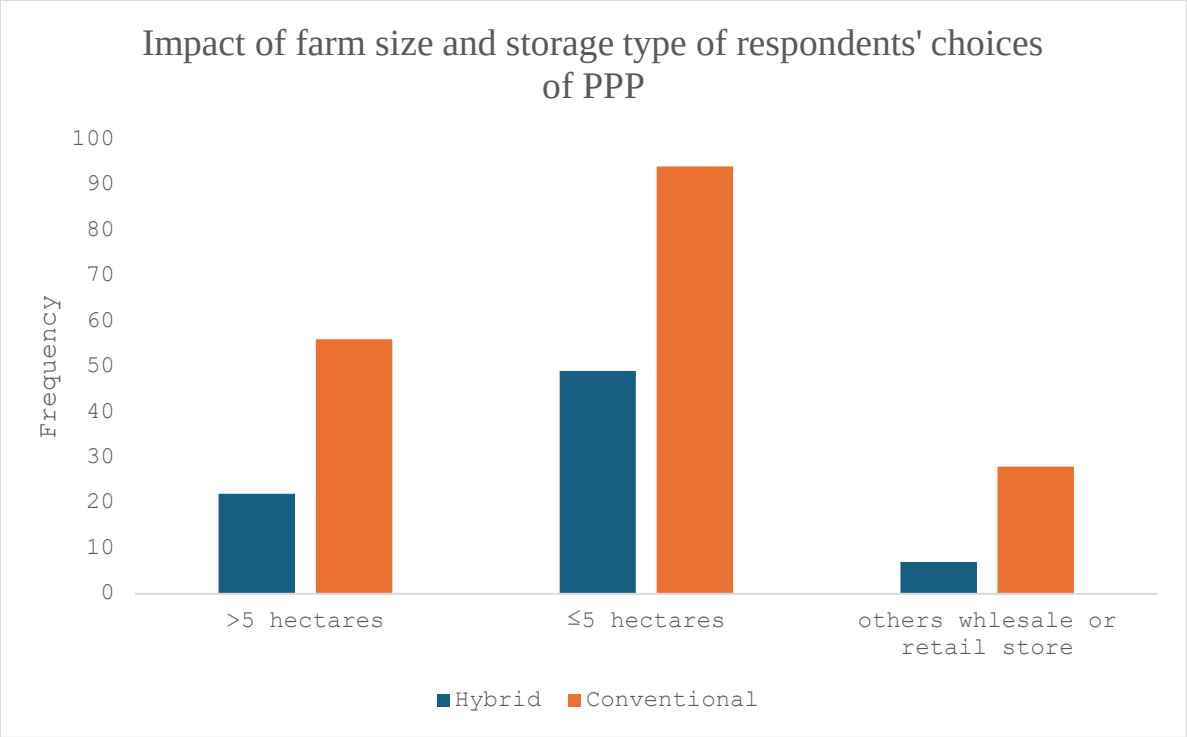


Figure 13. Distribution of the influence of farm size and storage scale on the choices of PPP

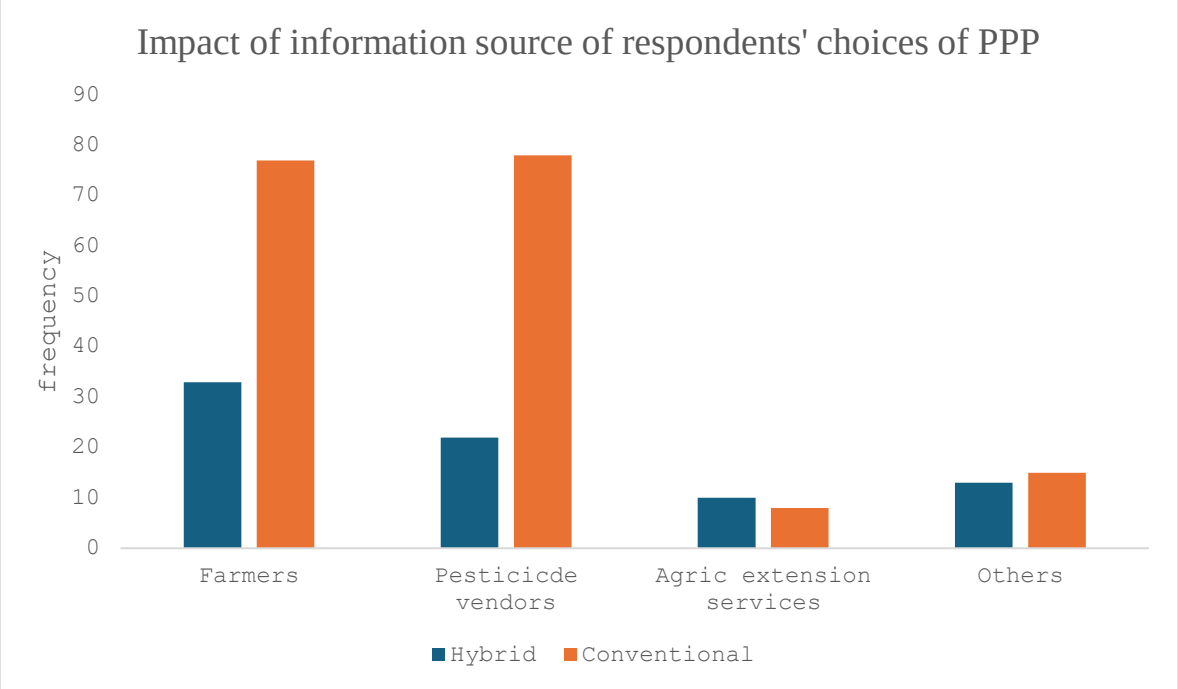
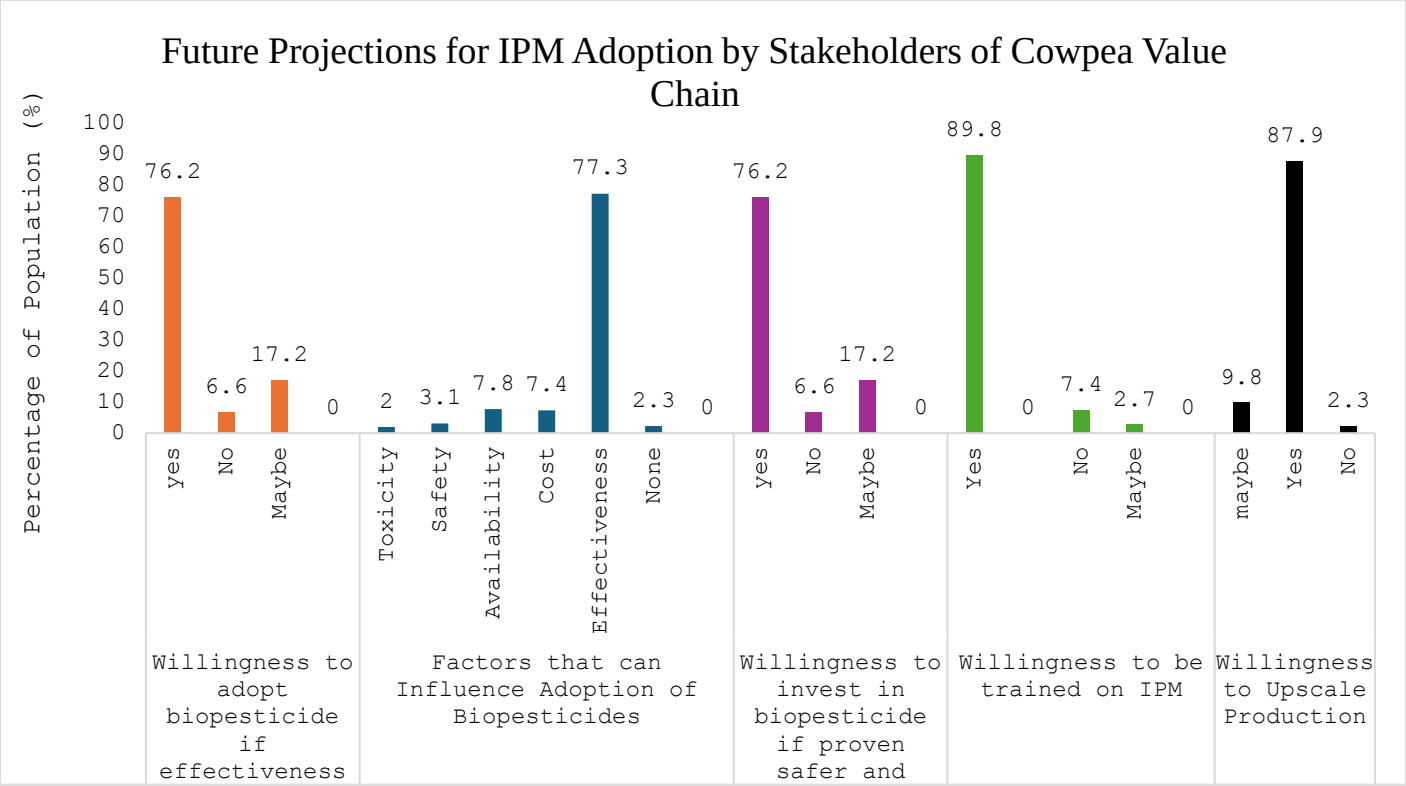


Figure 14. Distribution of the influence of sources of information on the choices of PPP

Source: Primary Data

The non-significant effect of farm size suggests that adoption decisions are not constrained by landholdings but by experience, knowledge, reliable information and perception of risk.

Overall, these results indicate gap in the availability and accessibility of effective and safer alternatives to conventional pesticides and the need to strengthen awareness campaigns that can enhance the adoption of safer PPPs.



Source: Primary data 2024

Figure 15. Prevailing pest control methods employed by farmers and storers of cowpea in Nigeria

In Fig. 11, The prevalence of conventional pesticide adoption among the survey population correlates with existing publications (Nwagboso et al., 2024). Inadequate education has been identified as one of the factors that influence such adoption (Nwagboso et al., 2024). However, Fig. 15 suggests that unavailability of equally effective safer alternatives to conventional pesticides significantly influences 76% of the population on the choice of PPPs to adopt. Also, 77.3% of the population identified effectiveness of biopesticides in pest mitigation as a potential factor that can improve adoption of IPM among stakeholders in Nigeria while 76% were willing to invest in the adoption of biopesticides if modified to be equally effective as conventional pesticides. Responses from 89.8% of the participants indicated subjective willingness to be trained in IPM strategies.

5. CONCLUSION

There is a significant imbalance between food security consciousness and food safety precaution among stakeholders in the survey population. Farmers and aggregators tend to prioritize food security over food safety to avert hunger and sustain trade as conventional pesticides remain the most prevalently adopted plant protection products in Nigeria with minimal guidance and precautionary measures observed on its use, storage and disposal. Inadequate availability of safer, affordable, sustainable and equally effective alternatives to conventional pesticides, minimal access to information on safe handling of PPPs and insufficient awareness creation, training and inclusion of rural stakeholders in the IPM strategy by relevant government regulatory authorities are the principal hinderances to the adoption of IPM among the population.

5.1 Limitations to the Study

The primary data generated from this research corroborates with existing data from several authors cited. However, due to selection bias, relatively smaller sample size (256) and social demographic differences, it may not be completely representative of the entire Nigerian population of stakeholders in the cowpea value chain.

5.2 Implication for Policy Practice or Further Studies

5.2.1 Insights into Research and Development

This study validates the need to explore Nigeria's wealth of biological resources and intensify further research on suitable and sustainable cutting-edge technology that is applicable in the valorization of these resources for formulation and production of bioinsecticides that are safer and equally effective as the mostly sought after conventional insecticides.

The reliance of cowpea producers on conventional pesticides ascertained in this study necessitates a multifaceted approach in proffering multiple solutions to the current ban and future unforeseen challenges. There is a need for further research on sustainable and safer organic-based PPP options to be made available to farmers and other agricultural stakeholders.

5.2.2 Insights on Government Policy Making and Strategic Planning

Nigeria being a signatory to the IPPC has structured policies that encourages food safety, food security and facilitation of international trade regulations in congruence with ISPM 2 and ISPM 14 which centers on pest risk analysis assessment and management. However, due to its large population and relatively low labor force in the respective government regulatory authorities that enforce food and agricultural laws and regulations, there may be lapses in the adequate flow of vital information to relevant stakeholders, hence strengthening inclusivity of stakeholders at the local government areas through

- Creation of capacity building programs and distribution of relevant materials.
- Simplification and translation of SOPs on pesticide application into native languages, comics or diagrams comprehendible by lay people at a cursory glance may improve adherence to the scope of good agricultural practices GAP amongst stakeholders.
- Development of collaborative policies that mandate students and researchers in fields relevant to agriculture and health to carry out food safety surveillance research at least once within the duration of their studies on specific value chains using standard SOPs. Such policies will enable inclusiveness of the academia in the development of food safety database in Nigeria.

Further research in this field of study involving a larger population of stakeholders and more value chains will be highly valuable in advancing food safety measures in Nigeria.

6. ACKNOWLEDGEMENT

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7. REFERENCE

Aveling T. (1999). *Cowpea pathology research*. www.ap.ac.za/academic/microbio/plant/pr-colwpea.html

Ayilara, M. S., Adeleke, B. S., Akinola, S. A., Fayose, C. A., Adeyemi, U. T., Gbadegesin, L. A., Omole, R. K., Johnson, R. M., Uthman, Q. O., & Babalola, O. O. (2023). Biopesticides as a promising alternative to synthetic pesticides: A case for microbial pesticides, phytopesticides, and nanobiopesticides. *Frontiers in Microbiology*, *14*, 1040901. https://doi.org/10.3389/fmicb.2023.1040901

Crop Life Intr. (2014). *Integrated Pest Management*. www.croplife.org

EU PE 653.622. (2021). The use of pesticides in developing countries and their impact on health and the right to food. *Policy Department for External Relations Directorate General for External Policies of the Union*, *PE 653.622*.

EU SUR. (2022). *Proposal for a Regulation of the European Parliament and of the Council on the Sustainable Use of Plant Protection Products and Amending Regulation (Eu) 2021/2115* (2022/0196 (COD)).

EU SUR. (2024). *Proposal for a Regulation on the Sustainable Use of Plant Protection Products-Q1-2022* [Legislative Train]. A European Green Deal.

FAO. (1986). *Food and Agriculture Organization of the United Nations. (1986). International code of conduct on the distribution and use of pesticides. Rome: FAO.*

FAOSTAT. (2023). *Crops and Livestock Products*. https://www.fao.org/faostat/en/#data/QCL

GAP Guideline MAFF Japan. (2022). *Guidelines on International-level GAP. Supplementary Provisions 3NOUSAN No. 3417*.

Hassan, Y., Zamani, H., & Varshney, D. (2018). *Preserving or Poisoning: A Case of Dried-Beans from Nigeria*. *8*. http://dx.doi.org/10.2139/ssrn.3462398

Ilesanmi, J. O., & Gungula, D. T. (2010). Preservation of Cowpea (*Vigna unguiculata* (L.) Walp) *Grains* against Cowpea Bruchids (*Callosobruchus maculatus*) Using Neem and Moringa Seed Oils. *International Journal of Agronomy*, *2010*, 1–8. https://doi.org/10.1155/2010/235280

IPPC Ukraine. (2013). *International phytosanitary standards- International Plant Protection Convention (IPPC)*.

Jha, A. K. (2024). Advances in Production in Technology of Cowpea. In *Advances in Production Technology of Tropical and Sub-Tropical Vegetable Crops,* (1st Chapter 23, Vol. 2024). Narendra Publishing House.

Joseph Otorkpa, O., Oche Otorkpa, C., Shnada Auta, H., & Anyalewachi Ukah, A. (2024). Pattern and Impact of Pesticide Poisoning: A Review of Published Case Reports. *Texila International Journal of Public Health*, *12*(2), 187–200. https://doi.org/10.21522/TIJPH.2013.12.02.Art016

Ilesanmi J.O.Y, I., & D.T., Gungula. (2016). Amino Acid Composition of Cowpea Grains Preserved with Mixtures OF Neem (Azadirachta indica) and Moringa (Moringa oleifera) Seed Oils. *American Journal of Food and Nutrition*, *4*(6), 150–156. https://doi.org/DOI:10.12691/ajfn-4-6-2

NAERLS. (2021). *National Report of Wet Season Agricultural Performance*. National Agricultural Extension and Research Liaison Services, Ahmadu Bello University. https://naerls.gov.ng/wp-content/uploads/2022/11/AgriculturalPerformance-Survey-of-2021-Wet-Season-in-Nigeria.pdf

NAFDAC. (2022). *Regulation and Control of Pesticides in Nigeria*. https://nafdac.gov.ng/press-release-on-the-regulation-and-control-of-pesticides-in-nigeria/

NAQS. (2018). *Nigeria Agricultural Quarantine Service ACT*.

Nat Commun 15, 222. (2024). Feeding the future global population. *Nature Communications*, *15*(1), 222, s41467-023-44588-y. https://doi.org/10.1038/s41467-023-44588-y

NESREA. (2020). *National Environmental (Hazardous Chemicals and Pesticides) Regulations* (143; Version Volume 101). https://www.nesrea.gov.ng/wp-content/uploads/2020/02/Hazardous_Chemicals_and_Pesticides.pdf (B851-891)

NPAC Core Manual. (2014). *National Pesticide Applicator Certification Core Manual* (Version Second Edition).

Nwagboso, C., Andam, K. S., Amare, M., Bamiwuye, T., & Fasoranti, A. (2024). The Economic Importance of Cowpea in Nigeria. *International Food Policy Reseach Institute*, *IFPRI Discusion paper 02241*. https://hdl.handle.net/10568/139672

Omoigui, L. O., Kamara, A. Y., Kamai, N., Ekeleme, F., & Aliyu, K. T. (2020). Guide to Cowpea Production in Northern Nigeria. *International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria*.

PCPB Kenya. (2019). *Guidelines for On-Farm Disposal of Pesticide Wastes and Containers. Pest Control Products Board*. https://www.pcpb.go.ke/wp-content/uploads/2019/08/Disposal_Guidelines.pdf

Sardar, H., Hadi, F., Alam, W., Halawani, I. F., Alzahrani, F. M., Saleem, R. A., Cerqua, I., Khan, H., & Capasso, R. (2024). Unveiling the therapeutic and nutritious potential of Vigna unguiculata in line with its phytochemistry. *Heliyon*, *10*(18), e37911. https://doi.org/10.1016/j.heliyon.2024.e37911

Statista. (2024). *Employment in Nigeria, Statistics and Facts.* Doris Dokua Sasu Statista. https://www.statista.com/statistics/1288834/employment-by-economic-sector-in-nigeria/

WHO and UNEP. (1990). *Public Health Impact of Pesticides Used in Agriculture*. World Health Organization. https://iris.who.int/handle/10665/39772

Wikipedia. (2025). List of countries by age at first marriage. In *Wikipedia, The Free Encyclopedia*. https://en.wikipedia.org/w/index.php?title=List_of_countries_by_age_at_first_marriage&oldid=1269059189

Worldometer. (2024). *World Population Prospects* (The 2024 Revision. (Medium-Fertility Variant)). United Nations, Department of Economic and Social Affairs, Population Division. www.worldometers.info