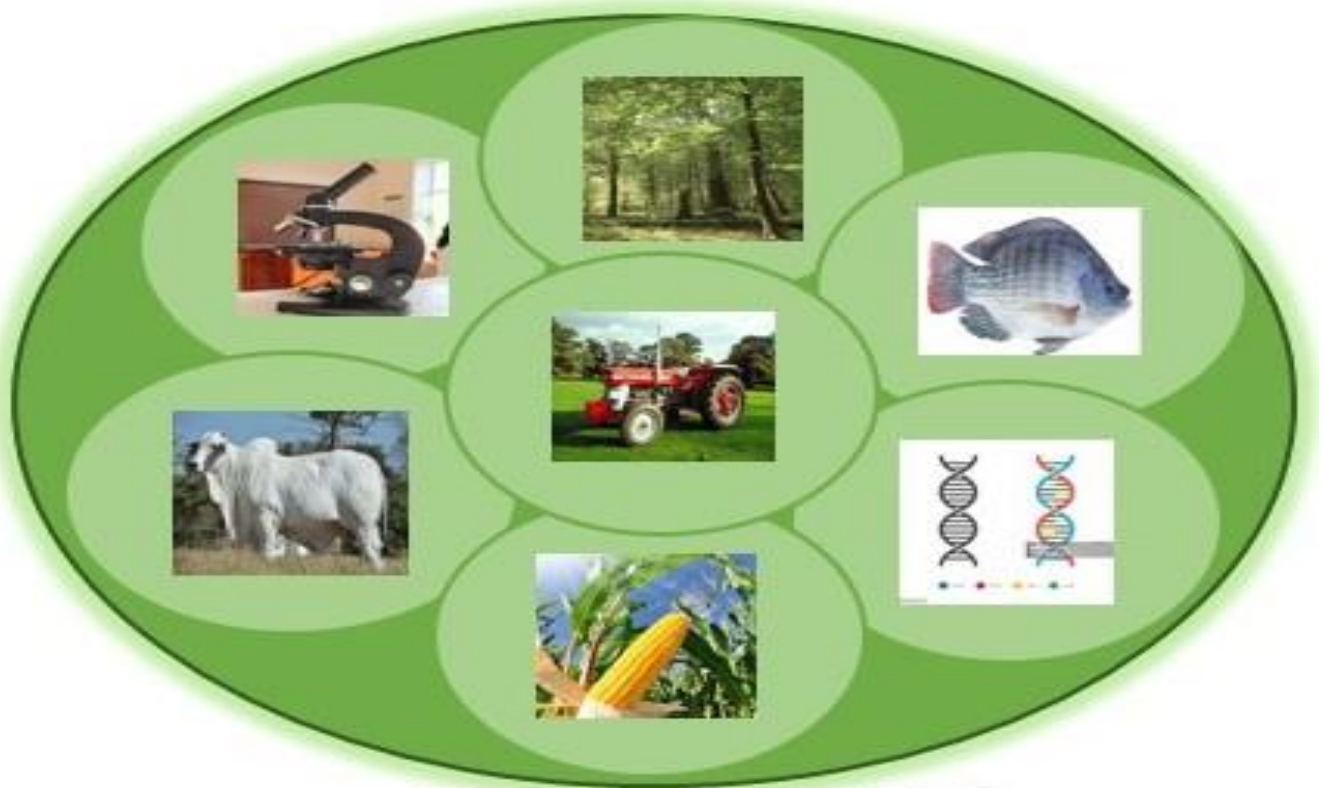




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The Kebbi Journal of Agriculture and Natural Sciences has the sole aim of providing an intellectual platform and ideas for scholars, by promoting interdisciplinary studies related to agriculture and natural science through publishing the latest scientific research findings that are of direct policy implications and beneficial to the research community. Consequently, the journal covers all aspects of Crop Science, Animal Science, Agricultural Economics, Agricultural Extension and Rural Development, Food Science, Fisheries and Aquaculture, Biotechnology, Soil Science and Agricultural Engineering, Forestry and Environment, Wildlife, Agricultural Education, Agro-allied Industries as well as all Natural Science researches related to Agriculture.

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ADOPTION OF PURDUE IMPROVED CROP STORAGE BAGS (PICS) AMONG COWPEA SMALLHOLDER FARMERS IN YAURI AGRICULTURAL ZONE, KEBBI STATE NIGERIA

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ABSTRACT

This study assessed the adoption of Purdue Improved Cowpea Storage (PICS) technology among cowpea farmers in the Yauri Agricultural Zone of Kebbi State, Nigeria. It described the socioeconomic characteristics of respondents, assessed their awareness of PICS technology, determine the extent of adoption, evaluate benefits derived, and identify constraints associated with PICS usage. A multi-stage sampling technique was used to select 300 cowpea farmers. Results showed that most respondents (76.0%) were male and aged between 21 and 60 years. More than half (53.3%) relied on personal savings as their main farming capital, while 47.0% used storage bags from previous harvests. Family size was large, with 28.0% having 16–20 members, and 35.0% had 11–15 years of cowpea farming experience. The majority (66.7%) cited insect pest prevention as the main benefit of using PICS bags, and 76.7% were fully aware of the technology. The research work concluded that Purdue improved cowpea storage technology was highly adopted with better improvement on cowpea storage quality and increased in cash inflow among cowpea farmers in the study area. Improving adoption of PICS technology in Yauri Agricultural Zone has strong potential to reduce post-harvest losses, enhance profitability, and contribute to rural livelihood improvement. Sustainable scaling will require coordinated efforts among government agencies, extension institutions, private manufacturers, and farming communities.

Keywords: Purdue Improved Cowpea Storage (PICS) technology, cowpea farmers

Introduction

Cowpea (*Vigna unguiculata* [L.] Walp) is the most important indigenous African legume crop, widely grown by small-scale farmers due to its economic and nutritional value, being rich in protein and consumed as a staple food while also serving as a source of income (Nounagnon *et al.*, 2024). West Central Africa accounts for 95% of global production, with Nigeria being the largest producer and consumer,

contributing up to 66% (Kirarei *et al.*, 2024). Despite its importance, production faces challenges, particularly insect pests and post-harvest storage losses caused mainly by bruchids (*Callosobruchus* spp.), which can cause 80–100% grain damage if uncontrolled (Berhe *et al.*, 2024; Sutradhar, 2022; Scot and Christina, 2020; Murdock, 2019). Post-harvest constraints force farmers to sell produce immediately at low prices, reducing potential profits (Togola *et*

al., 2023; Mujuka, 2023). Traditional and improved storage methods such as mud structures, underground pits, jute bag, plastic polythene bags, and metallic bins present limitations ranging from pest infestation, moisture absorption, and space requirements to susceptibility to theft (Okparavero *et al.*, 2024; Pasqualone, 2025; Murmu *et al.*, 2025; Sharma *et al.*, 2023).

To address these issues, controlled atmosphere storage based on hermetic storage principles was developed, targeting insect respiration through hypoxia and hypercarbia, though its artificial modification of gases makes it impractical at farmer level (Liu *et al.*, 2025; Yusuf and Ibrahim, 2023). A more practical innovation is the triple-layer hermetic Purdue Improved Crop Storage (PICS) bags developed by Purdue University, which provide insecticide-free, long-term storage of legumes and other grains (Baributsa and Ignacio, 2023; Murdock, 2019). This bag, consist two inner polyethylene liners and an outer woven polypropylene layer, prevent pest infestation by depleting oxygen and increasing CO₂ levels, thus extending grain quality and shelf life (Guru *et al.*, 2022; Magan, 2018). Compared to insecticides, which pose cost, health, and environmental risks, and ash treatment, which is laborious and unpopular (Hajam and Kumar, 2022; Badihe *et al.*, 2024), hermetic bags present safer alternatives. Statistics indicate Nigeria loses 10–30% of grain due to poor storage, but hermetic technology can reduce losses, improve food security, and allow farmers to sell at higher prices off-season (Murdock, 2019).

Currently, hermetic bag retail price is about ₦2000-₦3000 and are produced by certified manufacturers such as PICS, ZeroFly, Elite, GrainPro, and AgroZ (IITA, 2019). Trials by One Acre Fund Nigeria showed that PICS bag reduce losses, extend storage, and increased economic benefits of about \$4.96 over their three-year lifespan

(Murdock, 2019). Other storage forms like jute and polypropylene bags are prone to bruchid infestation, mold, and aflatoxin production, whereas polyethylene bags inhibit fungal growth and retain seed germination longer (Gaffar, 2019; Scot and Christina, 2020; Magan, 2018). Triple-layer hermetic bag have successfully stored cowpea, maize, and Bambara groundnut, preserving germinability and reducing pest damage, weight loss, and mold growth (Elsawy *et al.*, 2023; Murdock, 2019). Overall, PICS bag provides a sustainable, chemical-free, and ecologically safe approach to cowpea storage at the farmer level.

Cowpea research has largely overlooked storage and marketing, yet insect damage can cut yields by up to 95% (Murdock, 2019). As a result, many farmers sell immediately or rely on unsafe chemicals; losing potential income. Improving storage and marketing would greatly reduce losses and boost food security for both farmers and traders (Murdock, 2019). Nigeria's agricultural growth and poverty reduction depend on better storage, as poor and costly facilities cause high post-harvest losses and low returns. Improving cowpea storage and marketing can boost food security and incomes of farmers and marketers. This study supports farmers, traders, and policymakers by providing evidence for safer storage technologies and a foundation for further research.

Cowpea is a major food and income crop in Nigeria and across Sub Saharan Africa, but post harvest storage has received less attention than production related research. Poor storage conditions and insect infestation cause severe grain losses, sometimes reaching very high levels depending on environment and variety. Due to inadequate storage facilities and weak management practices, many farmers are compelled to sell immediately after harvest at low prices or use unsafe chemical

preservatives. These challenges reduce income for farmers and traders, lower grain quality, and limit the crop's contribution to food security and poverty reduction. The study aims to assess the adoption of PICS bags among cowpea smallholder farmers in Yauri Agricultural Zone, Kebbi State, specifically, it seeks to examine farmers' socio-economic characteristics, their awareness of PICS technology, and the extent of its adoption in the area. The general objectives of the study were to;

- i. Describe the socio-economic characteristics of the respondent
- ii. Assess the level of awareness of the Purdue improve cowpea storage technology bags among respondents
- iii. Determine extent of adoption of PICS technology among the respondents in the study area

Methodology

The Study Area

The study was conducted in Yauri Agricultural Zone, Kebbi State, about 215 km from Birnin Kebbi. The area, largely inhabited by the Kambari ethnic group, has

an estimated population of 160,000 and an average temperature of 31°C. It experiences dry and rainy seasons with significant agricultural activity, mainly cowpea, rice, maize, guinea corn, and groundnut cultivation. Yauri also hosts industries like sugarcane, rice milling, and tomato processing, alongside vibrant trade and untapped mineral resources (Gaffar, 2019). The study used a multi-stage sampling method. The first stage involves purposive selection of Yauri Agricultural Zone, due to its high concentration of cowpea farmers. In the second stage it involves random selection of three local government areas (LGAs) namely Yauri, Ngaski and Shanga. The third stage involves random selection of two communities from Yauri LGA which includes ~~Six villages~~ Tondi Tsamiya, Tondi Gada; also, in Ngaski LGA Birnin Yauri, and Warrah were selected. In Shanga LGA, Shanga, Dugu Tsoho, and Saminaka were randomly chosen. In the final stage 300 respondents were proportionately selected and giving a total of 1,800 respondents for the study (Table 1).

Table 1: Sample frame and Sample size of the Study

Yauri Agric Zone	Selected LGAs	Selected Villages	Population	Sample size
	Yauri	Tondi Tsamiya	311	50
		Tondi Gada	318	51
	Ngaski	B/Yauri	325	52
		Warrah	404	65
	Shanga	Dugu Tsoho,	352	56
		Saminaka	165	26
Total	3.0	6.0	1,875	300

Source: Field Survey, 2024

Data collection

Primary data was collected using structured questionnaire containing both open and close ended questions. While text books and Journals were used as reference materials.

Interpreters were used to assist in administering the questionnaire while, translating the questionnaire to those that cannot read or write in English.

Result and Discussion

Socioeconomic characteristics of the respondents

The results in Table 2 shows that most (76%) of the respondents were males, reflecting cultural values that limit women's participation in outdoor activities. This aligns with Jeanne (2017), who noted that cowpea storage in West Africa is male-dominated.

Results further shows that most (24%) of the respondents were between 41 and 50 years. This indicates that ages 41–50 are the most active in cowpea storage, supporting Baributsa (2020) who found this age group most productive in agricultural activities in Sub-Saharan Africa.

Furthermore, the result shows that many (80%) of the respondents had one form of education or the other, meaning all had some form of schooling and could read and write. This agrees with Ousmane (2020), who reported that most people in agricultural processing and preservation in West Africa had some form of education, aiding their knowledge in cowpea storage.

The result also reveals that close to half (45%) of the respondents acquired land through inheritance. This indicates inheritance as the dominant land tenure system, consistent with Ibrahim, *et al.* (2024) and Ousmane (2020), who found

most farmers in Kebbi State and Sub-Saharan Africa obtained land this way.

Moreso, evidence presented in Table shows that more than half (53.3%) of the respondents funded cowpea production through personal savings. This highlights personal savings as the main capital source, aligning with Baributsa *et al.*, (2020), who noted that Sub-Saharan African farmers rely on savings due to limited access to bank loans.

Furthermore, the findings shows that nearly half (47%) of the respondents sourced cowpea storage materials from previous harvests. This indicates diverse storage sources, corroborating with the findings of Stoll (2019), who reported similar patterns. The results further indicates that (28%) of the respondents had between 16 and 20 members, suggesting large families that support storage activities. This aligns with Olubayo (2021), who noted that most Sub-Saharan African farmers have household sizes of 5–20 members.

The results shows that many (35.3%) of the respondents had between 11 and 15 years of cowpea storage experience. This indicates that most of them had over 5 years' experience, aiding adoption of new storage technologies. The finding supports Olubayo (2019), who reported long storage experience among Sub-Saharan African farmers.

Table 2: Socio-Economic characteristics of respondents

Variables	Frequency	Percentage	Mean
Gender			
Male	228	76.0	
Female	72	24.0	
Age Range			
21 – 30	63	21.0	
31-40	59	19.7	
41-50	72	24.0	188.2
51-60	60	20.3	
61 and above	46	15.0	
Educational Level			
Primary Education	76	25.3	
Secondary Education	59	19.7	
Post-Secondary Education	82	27.3	
Non-formal Education	83	27.7	
Land Acquisition			
Purchase	87	29.0	
Inheritance	135	45.0	
Lease	48	16.0	
Communal	30	10.0	
Sources of capital			
Personal saving	160	53.3	
Banks	75	25.0	
Relatives	39	13.0	
Associations	26	8.7	
Sources of storage Material			
Previous Harvest	141	47.0	
Market	111	37.0	
Agencies (ADPs)	48	16.0	

Variables	Frequency	Percentage	Mean/ \pm standard deviation
House Hold Size			
1-5	44	14.7	54.2 \pm 0.04
6-10	61	20.3	
11-15	81	27.0	
16-20	84	28.0	
21 and above	30	10.0	
Years of being in cowpea storage			
1-5	39	13.0	54.2 \pm 0.04
6-10	91	30.3	
11-15	106	35.3	
16-20	45	15.0	
21 and above	19	6.3	
Total	300	100.0	

Source: Field Survey, 2024

Awareness of Purdue cowpea storage technology

Table 3 presents the level of awareness of Purdue Improved Crop Storage technology among the respondents and the sources through which the information was obtained. The findings indicate a very high level of awareness within the study area. A large majority of the respondents, 76.7 percent, were fully aware of the technology, while 22.3 percent were partially aware. Only 1.0 percent reported that they were not aware of the technology. This suggests that awareness of the storage innovation is widespread among cowpea farmers in the area. High awareness is a critical prerequisite for adoption, although it does not necessarily translate into complete or correct utilization. The proportion of partially aware respondents indicates that some farmers may have limited technical understanding of proper usage, which could affect effective implementation.

Regarding the source of awareness, the results show that friends and relatives were the dominant channel, accounting for 66.7 percent of responses. Extension agents accounted for 30.0 percent, while mass media contributed only 3.3 percent. The strong influence of friends and relatives suggests that informal social networks play a major role in disseminating agricultural innovations in the study area. Farmer to farmer interaction appears to be more influential than formal communication systems. Although extension agents contributed significantly, their role was secondary to interpersonal networks. The very low contribution of mass media indicates limited use of radio, television, or print platforms in promoting storage technologies. Overall, the findings reveal that awareness of the technology is high, but dissemination relies heavily on informal channels, which may affect the depth and technical accuracy of knowledge shared among farmers.

Table 3: Awareness of Purdue cowpea storage technology

Level of Awareness	Frequency	Percentage
Not aware	3	1.0
Partially aware	67	22.3
Fully Aware	230	76.7
Total	300	100
Source of Awareness		
Extension Agents	90	30.0
Friends and Relatives	200	66.7
Mass media	10	3.3
Total	300	100

Source: Field Survey, 2024

Adoption and benefits of Purdue Improved Cowpea Storage Technology among the respondents

The results in Table 3 show that all respondents adopted PICS technology at some level, with 33 percent fully adopting and 67 percent partially adopting it. There were no cases of non-adoption, indicating strong acceptance of the technology in the study area. However, the higher proportion of partial adopters suggests that many farmers may not yet be using it consistently or exclusively. This agrees with Olubayo (2019), who found similar trends in Sub-Saharan Africa.

Regarding benefits, most respondents, 66.6 percent, identified seed safety and protection from pests as the main advantage. Smaller proportions noted that the bags are flexible and reliable, reusable, and affordable. This indicates that effectiveness in preventing storage losses is the primary reason for adoption, while cost and durability are secondary considerations. It is in tandem with results Baributsa (2020) and Olubayo (2018), who highlighted PICS as reliable, affordable, and effective in preserving seed quality against pests.

Table 3: Adoption and benefits of Purdue Improved Cowpea Storage Technology among the respondents

Adoption Rate	Frequency	Percentage
Fully Adopted	99	33.0
Partially	201	67.0
Not Adopted	0	0.0
Total	300	100
Benefits of PICST		
Cowpea Seeds are Save	200	66.6
Not expensive	20	6.7
Flexible and Reliable	50	16.7
Can be use more than one time	30	10.0
Total	300	100.0

Source: Field Survey, 2024

The logistic regression results in Table 4 examine the factors influencing adoption of Purdue Improved Crop Storage Technology. The dependent variable is adoption status, while the independent variables include socioeconomic and institutional characteristics. The constant term is positive and statistically significant at 5 percent level, indicating that when all explanatory variables are held constant, the baseline likelihood of adoption remains high. Gender has a positive coefficient but is not statistically significant. This implies that being male or female does not significantly influence adoption decisions in the study area. The odds ratio of 1.183 suggests only a slight increase in likelihood, which is not meaningful given the high p value.

Age shows a positive and statistically significant effect at 1 percent level. The odds ratio of 2.146 indicates that an increase in age category more than doubles the likelihood of adoption. This suggests that older farmers are more likely to adopt PICS technology, possibly due to greater responsibility for storage decisions or accumulated experience in managing post harvest losses. Educational level has a positive coefficient but is not statistically significant. Although the odds ratio of 1.439 suggests that more educated farmers are somewhat more likely to adopt, the lack of statistical significance means education did not play a decisive role in this context. Land

acquisition is positive but not significant. This indicates that the mode of land ownership does not significantly influence adoption behaviour.

Source of capital has a negative coefficient and is not significant. This suggests that whether farmers rely on personal savings, loans, or other sources does not statistically affect adoption. Similarly, source of storage materials has a negative and insignificant effect. Household size has a negative and highly significant effect at 1 percent level. The odds ratio of 0.115 indicates that as household size increases, the likelihood of adoption decreases substantially. Larger households may face higher consumption pressures or financial constraints that limit investment in improved storage technology. Farming experience has a strong positive and highly significant effect. The odds ratio of 5.016 implies that experienced farmers are about five times more likely to adopt the technology compared to less experienced farmers. This highlights experience as a major driver of adoption, likely because experienced farmers better understand the economic losses associated with poor storage. Extension services show a positive but statistically insignificant effect. Although the coefficient suggests a positive relationship, the high p value indicates that access to extension services did not significantly determine adoption in this study.

Table 4: The logistic regression results

Variables	Coefficients	S E	Wald χ^2	P-Value	Odd ratio
Constant	1.937	0.683	8.037	0.005	6.940
Gender (X ₁)	0.168	0.315	0.283	0.595	1.183
Age (X ₂)	0.894	0.339	6.97	0.008	2.146
Educational level (X ₃)	0.364	0.330	1.219	0.209	1.439
Land acquisition (X ₄)	0.146	0.319	0.209	0.647	1.157
Source of Capital(X ₅)	-0.052	0.338	0.023	0.879	0.950
Source of Storage Materials (X ₆)	-0.088	0.320	0.075	0.784	0.916
Household size (X ₇)	-2.161	0.5041	8.259	0.000	0.115
Farming experience (X ₈)	1.625	0.447	15.212	0.0000	5.016
Extension services (X ₉)	0.447	0.449	0.993	0.319	6.940

Conclusion

This study examined the adoption of Purdue University's Purdue Improved Crop Storage (PICS) technology among smallholder cowpea farmers in Yauri Agricultural Zone of Kebbi State. The findings confirm that cowpea remains a critical food security and income crop in the study area, yet is highly vulnerable to post harvest losses caused mainly by bruchid infestation. Traditional storage systems such as jute bags, polypropylene sacks, mud structures, and chemical treatments remain widely used but are associated with pest damage, mold development, health risks, and reduced grain quality. The results show high awareness of PICS technology, with 76.7 percent of respondents fully aware of the technology. Social networks, particularly friends and relatives, were the dominant source of awareness, followed by extension agents. This suggests that informal diffusion channels play a stronger role than institutional communication systems in technology dissemination within the area. Adoption levels indicate that 33 percent of respondents fully adopted PICS bags, while 67 percent partially adopted. No respondent reported complete non adoption, which implies strong acceptance of the technology. Farmers reported major benefits including protection of cowpea seeds from pest damage, preservation of

grain quality, reusability, and affordability. These findings are consistent with earlier reports on the effectiveness of hermetic storage in suppressing bruchid activity through oxygen depletion and carbon dioxide accumulation. The logistic regression results indicate that household size had a negative and statistically significant influence on adoption, while years of storage experience had a positive and significant influence. The negative coefficient for household size suggests that larger households may face financial constraints or competing consumption pressures that limit full adoption. Conversely, experienced farmers are more likely to recognize the economic advantage of improved storage technologies and therefore adopt them.

Recommendations

1. Extension delivery systems should intensify training programs on hermetic storage technology. Practical demonstrations at community level will improve technical competence in correct bag sealing and handling, which is critical for maintaining hermetic conditions.
2. Given that household size negatively influenced adoption, financial interventions such as input

subsidies, revolving credit schemes, or cooperative purchasing systems should be introduced to improve affordability of PICS bags.

3. Since informal networks are major sources of awareness, structured farmer to farmer learning platforms should be encouraged. Model farmers who have successfully used PICS technology can serve as local champions for wider dissemination.
4. State and federal agricultural development programs should formally incorporate hermetic storage technologies into post-harvest management strategies to reduce national grain losses and strengthen food security.
5. Future studies should quantify economic returns using cost benefit analysis across multiple storage seasons to provide stronger empirical evidence for policy decisions. Longitudinal studies are also recommended to evaluate sustained adoption behavior and technology durability.
6. Farmers should be supported with market information systems to enable strategic off season sales. Improved storage without improved marketing strategy limits potential income gains.

References

- Badihe, E., Clementson, C. L., Senyah, J., and Hammed, A. (2024). Appraisal of post-harvest drying and storage operations in Africa: perspectives on enhancing grain quality. *AgriEngineering*, 6(3), 3030-3057.
- Baribusta, D., I. Lowenberg-DeBoer T. Abdoulaye and L. L. Murdock. (2020): Improve Cowpea Storage (PICS) Technology. Rep. 262nded Vol. E. West Lafayette: Purdue University, 2013. Department of Entomology. Oct. 2013. Web. 19 Nov. 2013.
- Baributsa, D., and Ignacio, M. C. C. D. (2023). Department of Entomology, Purdue University, Lafayette, Indiana, USA 2 Department of Agricultural and Biosystems Engineering, Iowa State University, Ames, Iowa 50010, USA 3 Institute of Agricultural and Biosystems Engineering, University of the Philippines Los Baños. *Ensuring performance of hermetic bag storage technology for food security and resource sustainability*, 8.
- Berhe, M., Subramanyam, B., Chichaybelu, M., Demissie, G., Abay, F., and Harvey, J. (2022). Post-harvest insect pests and their management practices for major food and export crops in East Africa: An Ethiopian case study. *Insects*, 13(11), 1068.
- Elsawy, H. I., El-Kholy, M. M., Mohamed, A. M., and Kamel, R. M. (2023). Efficacy of different multi-layer hermetic bags on the seed quality of the faba bean (*Vicia faba* L.) in outdoor storage condition. *Scientific Reports*, 13(1), 20653.
- Guru, P. N., Mridula, D., Dukare, A. S., Ghodki, B. M., Paschapur, A. U., Samal, I., and Subbanna, A. R. (2022). A comprehensive review on advances in storage pest management: Current scenario and future prospects. *Frontiers in Sustainable Food Systems*, 6, 993341.
- Hajam, Y. A., and Kumar, R. (2022). Management of stored grain pest with special reference to *Callosobruchus maculatus*, a major pest of cowpea: A review. *Heliyon*, 8(1).
- Ezra, K. K., Pixley, K. K., Pascaline, J., & Ezekiel, K. K. (2024). An overview

- on the Taxonomy, Distribution, Production and Economic Importance of Cowpea. *Journal ISSN, 3005*, 2181.
- Liu, L., Lin, H., Zhou, X., Zhang, Z., Zhang, Y., Deng, S., and Fan, W. (2025). Application of Modified Atmosphere Preservation Technology in Cherry Storage: A Review. *Agriculture, 15*(5), 462.
- Magan, N., Sanchis, V and Aldred, D. (2004). Role of spoilage of fungi in seed deterioration. In: *Aurora D.K* (Ed.). *Fungal Biotechnology in Agricultural, Food and Environmental Applications*. 28: 311-323. Midcourse 2000 Resarch Meeting, April 9-14, 2019. Senegal. p: 3-4. (Also. available at WWW.canr.msn.cdu/oerscas/cowpca/procced.pdi)
- Mujuka, E. A. (2023). *Potential Economic Impact and Willingness to Pay for Postharvest Technologies of Mangoes and Their Value-added Products Among Producers and Consumers in Kenya* (Doctoral dissertation, University of Nairobi).
- Ntoukam, G., Kitch, L. W., Shade, R. E., & Murdock, L. L. (1997). A novel method for conserving cowpea germplasm and breeding stocks using solar disinfestation. *Journal of Stored Products Research, 33*(2), 175-179.
- Murdock, L.L., Dogo, S.D., Ntoukam, G., Kitch, L and Shade, R.E. (2003.) Preservation of cowpea grain in sub-Saharan Africa-Bean/Cowpea CRSP contributions. *Field Crops Research*. 82: 169-178.
- Murmu, S. B., Nayak, L. K., Lakshmanan, A., Baite, H., Nayak, D., and Biswas, P. (2025). Improved food storage in jute packaging: an assessment of the current uses, constraints, and functional enhancements of jute bags and the potential of nonconventional jute-based paper packaging. *Journal of Food Science and Technology*, 1-14.
- Nounagnon, M., Roko, G., Agbodjato, N. A., Dah-Nouvlessounon, D., Babalola, O. O., and Baba-Moussa, L. (2024). Cowpea (*Vigna unguiculata*). *Potential Pulses: Genetic and Genomic Resources*, 58-77.
- Okparavero, N. F., Grace, O. O., Rukayat, Q., Jimoh, O. M., Ishola, T. D., Okunlade, A. F., and Akande, E. T. (2024). Effective storage structures for preservation of stored grains in Nigeria: A review. *Ceylon Journal of Science, 53*(1).
- Ousmane N. B; Baoua I; Haoua S; Laouali A; Larry L. M. and Dieudonne B. (2020). Comparative Study of Cowpea Storage Technologies in the Sahel Region of Niger. *Insects, 11*, 689; doi:10.3390/insects11100689. www.mdpi.com/journal/insects
- Bakoye, O. N., Ibrahim, B., Seyni, H., Amadou, L., Murdock, L. L., and Baributsa, D. (2020). Comparative study of cowpea storage technologies in the Sahel region of Niger. *Insects, 11*(10), 689.
- Scot and Christina (2020). "Sub-Saharan Africa news in brief: 25 March-9 April". Science. Dev Net Science and Development Network Retrieved 2008.04-13.
- Sharma, S., Semwal, A. D., Murugan, M. P., Khan, M. A., and Wadikar, D. (2023). Grain storage and transportation management. In *Cereal Grains* (pp. 269-296). CRC Press.
- Singh, B: Ajeigbe, H. A.; Tarawali, S. A.; Fernandez-Rivera, S.; and Abubakar, M. (2018).

- Singh, B. B., Ajeigbe, H. A., Tarawali, S. A., Fernandez-Rivera, S., & Abubakar, M. (2003). Improving the production and utilization of cowpea as food and fodder. *Field crops research*, 84(1-2), 169-177.
- Singh, N. P., Mishra, R. K., Bandi, S. M., & Kumar, N. (2023). Advances in pest management in pulses-based cropping systems under changing climate. In *Integrated Pest Management in Diverse Cropping Systems* (pp. 259-291). Apple Academic Press.
- Stoll, G. (2019). *Natural Crop protection in the tropics*. AGREOL, CTA publication. . Verlag
- Stoll, G. (2000). *Natural Crop protection in the tropics: Letting information come to life* (No. Ed. 2, pp. xi+-376).
- Sutradhar B. (2022). *Insect pest constraints in stored pulses* (doctoral dissertation, uttarbangakrishiviswavidyalaya).
- Togola, A., Datinon, B., Laouali, A., Traoré, F., Agboton, C., Ongom, P. O., and Tamò, M. (2023). Recent advances in cowpea IPM in West Africa. *Frontiers in Agronomy*, 5, 1220387.
- Yusuf, M., and Ibrahim, H. (2023). A comprehensive review on recent trends in carbon capture, utilization, and storage techniques. *Journal of Environmental Chemical Engineering*, 11(6), 111393.