Journal of Agripreneurship and Sustainable Development (JASD)
Volume 4, Number 4, December, 2021
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365

ADOPTION OF PURDUE IMPROVED COWPEA STORAGE IN NORTH-EAST NIGERIA

[1]Murtala, N., [1]Yakubu, S., [1]Muhammad, I., [1]Danwanka, H., [1]Garba, M., [1]Fagam, A. S., [1]Sani, M. H., [2]Musa, S. A., [3]Bakori, A. M., [4]Lawal, H. and [5]Sulumbe, I. M.
[1]Abubakar Tafawa Balewa University, Bauchi
[2]Kano University of Science and Technology, Wudil
[3]Bayero University, Kano
[4]Modibbo Adama University of Technology, Yola
[5]University of Maiduguri
Corresponding Author's E-mail: nasirumurtala@yahoo.com **Tel.:** 08022170842

ABSTRACT
The study explored the general adoption of Purdue improved cowpea storage (PICS) technology in the fragile north-eastern Nigeria. Multi-stage sampling approach was used to select 3,000 respondents from the study area. The primary data for this study were collected in 2020 through a field survey conducted by the researchers through the use of structured questionnaire. Both descriptive and inferential statistics (Propensity score matching [PSM] and Inverse probability weighted regression adjusted [IPWRA]) were used. ATBU-PICS project had increased the adoption by 8-25 PICS bags with a standard error of 11.30-14.11 using different matching algorithm. The adoption was found to be influenced positively by age, years of formal education, participation into ATBU-PICS, knowledge of PICS technology and farm size at P≤0.01, P≤0.01, P≤0.01, P≤0.01 and P≤0.05, respectively. Sex and farming experience negatively affected the adoption of PICS at P≤0.01 and P≤0.01, respectively. The study therefore, concluded that the age, years of formal education, participation into ATBU-PICS, knowledge of PICS technology and farm size were the factors that influenced adoption of PICS in the study area. It was recommended that more awareness creation is needed to generate more PICS technology knowledge so as to achieve further penetration and further project should be initiated to complement the previous efforts in the study area.

Keywords: Adoption, Impact, PICS, PSM, IPWRA, North-east Nigeria.

INTRODUCTION
Global food systems produce enough food to feed everyone, but nearly one third of food produced in the world for human consumption is lost or wasted every year. The cost of this food loss and waste amounts to roughly USD 310 billion in developing countries (Food and Agriculture Organization [FAO], 2011). The key technology revealed by Larry Murdock and co-workers was in the form of the triple layer PICS bags. They are a cost effective, scale neutral technology for cowpea storage. PICS bags are composed of an outer layer of ordinary woven polypropylene and two inner liners of high-density polyethylene (HDPE), 80 microns thick (Baributsa *et al*., 2010). Purdue improved crop storage bags prevented germination loss, grain damage and weight loss due to pulse beetle up to 6 months of storage, infestation of grains by bruchids was relatively lower as they contain triple layers of air tight storage and relatively had highest benefit cost ratio compared to jute bag storage over 6 months of storage period (Nwaubani *et al.*, 2020). Following COVID-19 restriction in Kenya, the Households with improved storage had lower food insecurity, i.e., were more food secured compared to others (Huss *et al.*, 2020).

Journal of Agripreneurship and Sustainable Development (JASD)
Volume 4, Number 4, December, 2021
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365

North-east Nigeria has been engulfed with high incidence of armed conflict which is a major hurdle to growth of the agricultural sector and to economic development more broadly in sub-Saharan Africa (SSA) is the high incidence of conflict within the region (Avuwadah *et al.,* 2020). The adoption of agricultural technologies is largely determined by the socio-economic characteristics, institutional factors and technological characteristic. This partly informed the complementation of ATBU-PICS project to that of IITA in promoting the technologies among farmers in north-eastern Nigeria. Several extension delivery approaches were also used in promoting the Triple Bagging Technology as an improved way of crop storage. Since the commencement of the promotion of PICS technology in northeastern Nigeria in 2015, there appears to be no empirical study carried out to examine the adoption of PICS technology. The study adds to the literature on the impact of ATBU-PICS project on the adoption of PICS technology. Thus, the study aimed at achieving the following objectives:

i. examine the adoption of PICS technology in the study area; and
ii. determine the factors influencing the adoption ATBU-PICS project the technology in the north-east Nigeria
iii. examine constraints to the adoption ATBU-PICS project the technology in the north-east Nigeria

MATERIALS AND METHODS

The Study Area

This study was conducted in north-eastern Nigeria which consists of six states. The States are Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe. The study area is located between Latitude 9^0 08' to 14^0N and Longitude 8^0 68' to 15^0E. The area occupies a land mass of 280,419 km^2 (National Bureau of Statistics [NBS], 2017). According to National Population Census [NPC], 2020), the region has a population of 29, 470, 062 people based on 2006 annual population growth rate of 3%. The main economic activities in the area include; farming (crop and livestock), hunting, fishing, food processing, transportation and craft with inputs largely sourced from government. The average population density is 89 persons per Km^2, while the mean annual rainfall ranges from less than 250 mm in the Northern Sahel to 1500 mm in the derived savannah in line with southern part, and has a unimodal pattern (NPC, 2006). The study area is the major cowpea producing areas in Nigeria owing to its climate which favors growth of the crop. Being a largely Sahelian zone, insect pests (both field and storage) form a serious barrier to cowpea production and storage. The status of northeastern Nigeria as a major cowpea producing and the high incidence of pests formed the basis for the implementation of the PICS project in the area which started in 2009.

Sampling Procedure

A multi-stage random sampling technique was used in selecting the respondents. In the first stage simple random sampling was used in select 10 local government areas (LGAs) in each State of the study area. In the second stage, five (5) villages were selected randomly based on a list of villages on the map of the study area. In the final stage, the respondents for interview were randomly selected based on the list of the farmers taken during stakeholders meeting and village level demonstration. Five hundred (500) questionnaires were administered in each of the six States of the study area: Adamawa, Bauchi, Borno Gombe, Taraba, and Yobe States making a sample of 3,000 respondents.

Data Collection

The primary data for this study were collected in 2020 using structured questionnaires. The six (6) States of the study area were: Adamawa, Bauchi, Borno Gombe, Taraba, and Yobe States.

Journal of Agripreneurship and Sustainable Development (JASD)
Volume 4, Number 4, December, 2021
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365

Method of Data Analysis

A combination of both descriptive and inferential data was used in analyzing the data. Descriptive statistics used were frequency, percentage and mean while the inferential statistics used was double hurdle.

1. Double-hurdle model: The specification of the generalized double-hurdle model is as follows and was used in determining the intensity of adoption.

$$(1) \qquad y = \begin{cases} x'\beta + v & \text{if } x'\beta + v > 0 \text{ and } z'\alpha + u > 0 \\ 0 & \text{otherwise} \end{cases}$$

$$\begin{bmatrix} u \\ v \end{bmatrix} = N\left\{0, \begin{bmatrix} 1 & \rho\sigma \\ \rho\sigma & \sigma^2 \end{bmatrix}\right\} \quad \text{where } v > -x'\beta,$$

where;

y is the adoption; *x* and *z* are variables determining the adoption process; and; the adoption intensity process respectively; *u* and *v* are residual terms from those two processes, with a correlation coefficient ρ ; α , β , ρ , and σ are parameters for estimation. Then the likelihood function can be written as

$$(2) \qquad \begin{aligned} L = & \prod_{y=0} \{1 - \psi(z'\alpha, x'\beta/\sigma; \rho)/\Phi(x'\beta/\sigma)\} \\ & \times \prod_{y>0} \{\frac{1}{\sigma}\phi[(y - x'\beta/\sigma]\Phi[\frac{z'\alpha + \rho(y - x'\beta)/\sigma}{(1-\rho^2)^{1/2}}], \\ & \times [\Phi(x'\beta/\sigma)]^{-1}\}, \end{aligned}$$

where;

Φ(·) and φ (·) are univariate standard normal CDF and PDF respectively; ψ (·) is the bivariate standard normal CDF with three arguments, bivariate means and the error term correlation. When ρ = 0, the above model reduces to Cragg's independent hurdle model. When ρ = 0, *x* = *z*, and α = β /σ, it leads to the Tobit model. In this analysis, we used one set of explanatory variables for both processes, *x* = *z*, so that we can test our generalized hurdle model against Cragg's independent hurdle model and Tobit model.

RESULTS AND DISCUSSION

Respondents' Sex, Level of Education, Marital Status and Primary Occupation

The results in Table 1 show that majority (87.45%) of the respondents on Purdue Improved Cowpea Storage (PICS) were males in North East, Nigeria. The results also show that 21.88%, 21.58%, 19.61% and 18.75% of the surveyed farmers had primary education, secondary education, diploma/NCE and Islamic education, respectively. The findings from Table 1 reveals that most (89%) of the interviewed farmers were married in the study area.

According to the results (Table 1), the average age of the respondents was 46.2 years in the study area with maximum and minimum years of 75 and 20 years, respectively. These results indicate that most of the PICS beneficiaries were in their active age, hence, have more tendencies to utilize any technology. As shown in Table 1 the average years of education in the study area was 11 with 39 as the maximum years of education. On the other hand, the average years of farming experience was 13 with a maximum of 9.

It is evident from the results in Table 1 that farmers in the study area cultivate an average of 3.6 hectares with a maximum of 12.

Journal of Agripreneurship and Sustainable Development (JASD)
Volume 4, Number 4, December, 2021
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365

Table 1: Distribution of Respondents based on Sex, Level of Education and Marital Status

Variable		Adamawa		Bauchi		Borno		Gombe		Taraba		Yobe		Pooled	
		Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Sex	Female	81	16.1	13	2.59	62	12.50	35	7.10	130	26.10	53	10.91	62	12.55
	Male	422	83.90	488	97.41	433	87.50	459	92.91	368	73.90	433	89.09	434	87.45
	Total	503	100	501	100	495	100	494	100	498	100	486	100	496	100
Highest education level	Adult education	33	6.56	31	6.20	40	8.03	30	6.00	49	10.14	31	6.25	36	7.20
	Islamic/Qur'anic education	57	11.33	65	12.97	37	7.40	127	25.30	85	17.60	188	37.90	93	18.75
	Primary education	74	14.71	119	23.75	259	52.01	40	7.97	107	22.15	53	10.69	109	21.88
	Secondary Education	161	32.01	136	27.15	56	11.24	113	22.51	122	25.26	56	11.29	107	21.58
	Diploma/NCE	140	27.83	111	22.16	60	12.05	105	20.92	82	16.98	88	17.74	98	19.61
	Degree	30	5.96	32	6.39	34	6.83	75	14.94	33	6.83	71	14.31	46	9.21
	Postgraduate	8	1.59	7	1.40	10	2.01	12	2.39	5	1.04	9	1.81	9	1.71
	Total	503	100	501	100	496	100	502	100	483	100	496	100	497	100
Marital status	Single	27	5.40	34	6.79	22	4.40	39	7.80	71	14.17	47	9.49	40	8.01
	Widowed	11	2.19	7	1.40	20	4.03	5	0.99	11	2.20	0	0.00	9	1.80
	Divorced	6	1.19	5	1.00	9	1.81	1	0.20	12	2.40	1	0.20	6	1.13
	Married	459	91.25	455	90.82	445	89.72	458	91.05	405	80.84	447	90.30	445	89.00
	Total	503	100	501	100	496	100	503	100	499	100	495	100	500	100

Journal of Agripreneurship and Sustainable Development (JASD)
Volume 4, Number 4, December, 2021
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365

Table 2: Distribution of Respondents based on Age, Household Size, Years of Education, Cowpea Farming Experience and farm size

Variable		Age	Household size	Year of education	Cowpea farming experience	Total farm size
Adamawa	Mean	46.2	7.6	10.6	12.6	3.6
	Std. Deviation	9.4	4.6	5.1	8.7	1.7
	Min.	20	0	0	0	0
	Max.	75	30	39	60	12
Bauchi	Mean	42	8.8	14.4	11.9	3.6
	Std. Deviation	9.9	6.4	89.6	8	1.96765
	Min.	20	1	1	0	0
	Max.	70	55	20	40	10
Borno	Mean	41.809	7.743	8.357	14.202	2.24
	Std. Deviation	11	4.6	8.7	9.4	1.3
	Min.	18	1	0	0	0
	Max.	72	40	50	50	7
Gombe	Mean	43.7	9.6	10.9	16.5	6.8
	Std. Deviation	11.5	5.6	5.7	11.9	6.7
	Min.	20	1	0	0	0.3
	Max.	73	32	35	60	65
Taraba	Mean	40.5	7.9	9	10.5	5.4
	Std. Deviation	12.5	5.3	5.3	8.3	4.4
	Min.	18	1	0	0	0
	Max.	78	45	30	50	35
Yobe	Mean	41.4	6.6	9.5	9.9	5.5
	Std. Deviation	11.6	5.7	6.4	7.8	4.7
	Min.	18	1	0	0	0
	Max.	75	30	28	50	50
Pooled	Mean	42.6	8	10.5	12.6	4.5
	Std. Deviation	11	5.4	20.2	9	3.5
	Min.	19	0.83	0.17	0	0.05
	Max.	73.8	38.7	33.7	51.7	29.8

Level of Adoption of PICS Technology by the Respondents in the Study Area

Table 3 showed that the farmers that adopted the PICS technology were majority (85.3%) in the study area and this depicts the level of acceptance of the technology by farmers

Journal of Agripreneurship and Sustainable Development (JASD)
Volume 4, Number 4, December, 2021
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365

in the study area. This may not be unconnected with the effectiveness of the technology in improving the quality of the grains for better marketing.

Table 3: Level of Adoption of the Respondents

Adoption Status	Frequency	%
Non-Adopter	450	14.97
Adopter	2,556	85.03

Drivers of Adoption of PICS Technology in the Study Area

The rate of adoption is here defined as the share of PICS bags in use. The result (Table 4) showed that the Wald chi square was 261.85 (significant at P≤0.01), this proved the reliability of the model in assessing the drivers for adoption of PICS technology in the study area.

Table 4: Factors Influencing Adoption of ATBU-PICS Technology

Variable	Odds ratio	Robust Std. error	Z-value	P>|z|
Age	1.033	0.009	3.630	0.000
Sex	0.498	0.096	-3.600	0.000
Household size	0.999	0.016	-0.050	0.958
Years of formal education	1.030	0.012	2.640	0.008
Farming experience	0.969	0.010	-2.970	0.003
Farm size	1.061	0.032	1.980	0.047
Participation	14.882	2.692	14.930	0.000
Availability of PICS bags	1.090	0.178	0.530	0.598
Knowledge	2.108	0.188	8.340	0.000
Constant	0.178	0.057	-5.370	0.000
Wald Chi-square (10)	261.85***			
Pseudo R-square	0.3839			
Log pseudolikelihood	-523.235			

The result further showed that age, years of formal education, participation, knowledge and farm size were found to be positively significant at P≤0.01, P≤0.01, P≤0.01, P≤0.01 and P≤0.05, respectively. Sex and farming experience were found to be negative but significant at P≤0.01 and P≤0.01, respectively.

The Age of the farmers was found to be positively significant (P≤0.01), this implied that as the age increases by one year, the likelihood of being an adopter of PICS technology also increases by 1.33 when other variables were kept constant. This is possibly due to the fact that old farmers tend to choose safer way of storage that had no residual effect on them or their younger counterparts.

Sex was found to be negative but significant (P≤0.01), this revealed that female farmers were more likely to be adopters by 0.50 when other variables were kept constant. Years of formal education was found to be positively significant (P≤0.01), this depicts that as education increases by one year, the farmer odds of becoming an adopter increases by 1.03 if other variables were kept constant. It's likely due to the fact that educated people strived to reduce hazards in their lives and wisely accept technologies that were in conformity with their past knowledge, especially when it is cost effective. Educated people are also in better position to

understand the benefits of cowpea storage both from economic and health perspective and hence tend to use the technology more. This corroborates Muriithi *et al.,* 2021) who found education level to affect adoption of climate smart agriculture technology among smallholder farmers in Machakos, Makueni, and Kitui Counties of Kenya. This is contrary to the assertions of Moussa *et. al.* (2014) and Udimal *et al.* (2017) who found negative effect of education on the adoption of PICS technology and NERICA in Burkina Faso and Ghana, respectively.

Farming experience was found to be negative but significant (P≤0.01), this showed that as farmer adds a year of experience, he is less likely to be an adopter of PICS technology. This is contrary to *a priori* expectation but it might not be unconnected with other alternative hermetic storage methods that farmers might choose due to issue of insufficient supply of PICS bags to local communities.

Farm size was also found to be positively significant (P≤0.05), this implied that as farm increases by one hectare, the probability of farmer to be an adopter increases by odds of 1.06. This is probably due to human nature of striving to get a safer and economically rationale way of doing things. Farm surplus are been stored properly with PICS technology for future use.

Participation in ATBU-PICS project was positively significant (P≤0.01), this showed that as farmer participates in ATBU-PICS project, his odds of being an adopter increases by 14.89. This might not be unconnected with the proper training and the supply of the PICS bags at local communities. This corroborates the findings of Moussa *et al*. (2014) who found that living in a village where PICS demonstrations occurred has the impact on adoption in eight of the nine West African countries regressed. Only in Democratic republic of Chad was the PICS village variable not significant. It should be noted that in six of the nine regressions, participation in the PICS demonstrations had a statistically significant positive effect over and above living in a community where PICS activities were implemented.

Knowledge of PICS technology was found to be positively significant (P≤0.01), this means that as the farmers' PICS technology knowledge increases by one score, the odds of him being an adopter increases by 0.18. This revealed the importance of training campaign in awareness creation that results into subsequent adoption of PICS technology. This might be as results of farmers learning new technologies for them to practice it in their farms.

Respondents Perception on Constraints Associated PICS Bags

According to the results in Table 4, the respondents perceived that the major constraints to the use of PICS bags are: price of the bags is too high (63.6%), unavailability of the PICS bags (59.8%), rodents attack (32.2%) and inadequate training (30.1%). Other constraints include theft (23.7%), location of vendor unknown (20.8%) and technically cumbersome (19.7%).

Journal of Agripreneurship and Sustainable Development (JASD)
Volume 4, Number 4, December, 2021
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365

Table 4: Respondents' Perceived Constraints Associated with Use of PICS Bags

Constraints Associated PICS Bags	Adamawa		Bauchi		Borno		Gombe		Taraba		Yobe		Pooled	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Unavailability of the PICS bag	316	63.6	289	79.0	274	57.3	219	56.9	168	66.1	174	35.9	240	59.8
Price is too high	369	74.4	344	79.1	184	41.6	323	73.9	159	46.2	318	66.1	283	63.6
Location of vendor unknown	35	8.8	226	57.7	84	20.9	61	18.3	30	13.6	22	5.6	76	20.8
Inadequate training	24	5.9	238	58.6	203	40.8	137	33.3	44	17.9	118	24.0	127	30.1
It's technically cumbersome	12	4	168	45.4	80	20.3	60	17.9	23	18.4	49	12.4	65	19.7
Theft	60	19.5	192	53.5	41	10.3	64	19.2	59	37.1	10	2.6	71	23.7
Rodents attack	154	38.6	151	42.9	37	9.3	130	35.2	132	57.1	40	10.1	107	32.2
Fire outbreak	35	11.6	88	26.4	5	1.3	97	27.7	38	27.1	6	1.5	45	15.9
Long storage period	18	6	112	32.1	5	1.3	49	14.6	37	28.9	2	0.5	37	13.9
Poor quality of beans	0	0	81	24.8	67	16.9	62	17.7	75	42.9	3	0.8	48	17.2
Mould growth and grain rot	0	0	68	21.7	13	4.4	74	20.4	9	8.3	2	0.7	28	9.2

CONCLUSION AND RECOMMENDATIONS

The study explored the adoption of PICS technology in north-eastern Nigeria. Based on the findings, ATBU-PICS project had impacted on the adoption of PICS technology in north-eastern Nigeria with an adoption rate of 85%. The adoption was influenced positively by age ($P \leq 0.01$), years of formal education ($P \leq 0.01$), participation into ATBU-PICS ($P \leq 0.01$), knowledge of PICS technology ($P \leq 0.01$) and farm size ($P \leq 0.05$). Based on the findings, it was recommended that:

(i) more awareness creation is needed to generate more PICS technology knowledge so as to achieve further penetration; and
(ii) further project should be initiated to complement the previous efforts in the study area.

REFERENCES

Avuwadah, B. Y., Kropp, J. D., Mullally, C. C. and Morgan, S. N. (2020). *Heterogenous effects of conflict on agricultural production patterns: Evidence from Nigeria* (No. 304417). Agricultural and Applied Economics Association.

Baributsa, D., Lowenberg-DeBoer, J., Murdock, L. and Moussa, B. (2010). *Profitable chemical-free cowpea storage technology for smallholder farmers in Africa: opportunities and challenges.* In: 10th International Working Conference on Stored-product Protection, June 27th, July 2, 2010, Estoril, Portugal. http://pub.jki.bund.de/index.php/JKA/issue/view/719

FAO (2011). *SAVE FOOD: Global Initiative on Food Loss and Waste Reduction.* Rome. [Cited September 2019]. www.fao.org/save-food/resources/key-findings.

FAO (2020). *Nigeria at glance.* Available at: http://www.fao.org/nigeria/fao-in-nigeria/nigeria-at-a-glance/en/.

Huss, M., Brander, M., Kassie, M., Ehlert, U. and Bernauer, T. (2020). Improved storage mitigates vulnerability to food-supply shocks in smallholder agriculture during the COVID-19 pandemic. *Global Food Security*, *28*, 100468.

Moussa, B., Abdoulaye, T., Coulibaly, O., Baributsa, D. and Lowenberg-DeBoer, J. (2014). Adoption of on-farm hermetic storage for cowpea in West and Central Africa in 2012. *Journal of Stored Products Research*, *58*, 77-86.

National Population Commission [NPC] (2006). Available at: https://www.worldometers.info/world-population/nigeria-population/.

NBS (2020). *Population and Vital.* Available at: https://nigerianstat.gov.ng/elibrary?queries[search]=population.

NBS (2020). *Nigerian Gross Domestic Products Report 2020 (Q1, Q2, Q3 and Q4).* Available at: https://nigerianstat.gov.ng/elibrary?queries[search]=GDP.

Muriithi, L. N., Onyari, C. N., Mogaka, H. R., Gichimu, B. M., Gatumo, G. N. and Kwena, K. (2021). Adoption Determinants of Adapted Climate Smart Agriculture Technologies among Smallholder Farmers in Machakos, Makueni, and Kitui Counties of Kenya. *Journal of Agricultural Extension*, *25*(2), 75-85.

Nwaubani, S. I., Otitodun, G. O., Ajao, S. K., Opit, G. P., Ala, A. A., Omobowale, M. O., Ogwumike, J. C., Abel, G. I., Ogundare, M. O., Braimah, J. A., Gbengoa, B. S., Olenloa A. E., Kolayemi, O. R., McNeill, S. G. and Ileleji, K. E. (2020). Assessing efficacies of insect pest management methods for stored bagged maize preservation in storehouses located in Nigerian markets. *Journal of Stored Products Research*, *86*, 101566.

Udimal, T. B., Jincai, Z., Mensah, O. S. and Caesar, A. E. (2017). Factors influencing the agricultural technology adoption: The case of improved rice varieties (Nerica) in the Northern Region, Ghana. *Journal of Economics and Sustainable Development*, *8*(8), 137-148.