IJAAR PUBLISHING®
DOI: 10.46654
African Journal of Sustainable Agricultural Development | ISSN: **2714-4402**
Vol. 4, Number 1 (January-March, 2023) | www.ijaar.org/ajsad

ADOPTION OF HERMETIC BAG TECHNOLOGY AMONG SMALL HOLDER COWPEA AND MAIZE FARMERS IN THE FEDERAL CAPITAL TERRITORY (FCT), ABUJA

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Abstract
Huge quantities of harvested grains are stored in traditional ways thereby leading to food losses. Hence the need for technical improvement in grain storage structures. This article exposed quantifiable evidence on the state of adoption of hermetic storage bag technologies. Multi-staged sampling procedure was used and a structured questionnaire on the kobo collect software was used to elicit information from 170 farmers. The study used descriptive statistics and inferential statistics (Logit regression model) to analyse the data using STATA version 13.0 software. The study revealed that majority (71%) of the farmers were male, (80.59%) of the farmers were married and the mean age and farming experience were 47 years and 18 years respectively. About (39%) of the farmers attended secondary school education. The mean monthly income was found to be ₦42, 902.94 while an average of 17 extension contacts per annum were recorded. Among the indigenous systems of storage used are jute sack which had the greatest percentages of usage with (59.41%). On sources of Information available to the farmers, Agricultural Extension Officers ($\bar{x}$ = 3.40) ranked highest. On the stages of adoption, greater majority (51.8%) of the farmers had adopted the technology. From the regression result, monthly income (0.00003), extension contact per annum (0.042)* and educational qualification (0.36)* were only significant at 10% level of probability. Whereas, only sex (-0.33)** was significant at 5% level of probability. The adoption numbers are not all that fantastic considering the percentage of farmers still unaware such a technology exists. The efforts of the agricultural extension officers in collaboration with other agencies and nongovernmental organizations should play a pivotal role in facilitating the rate of adoption.*

Keywords: Postharvest losses, Acceptance, utilization, storage bag, and Abuja.

Introduction

The food commodities of special interest in this research are Cowpea and Maize. Cowpea (*Vigna unguiculata*) is the most important indigenous African legume. It is consumed on a daily basis as a staple food in both urban and rural West and Central Africa. Eighty-Four percent of the world's production area and 83.4% of the world's overall production of cowpea is from Africa, with over 80% of African production in West Africa. According to the Food and Agricultural Organization Corporate Statistical Database FAOSTAT (2016), cowpea was grown on an estimated 12.3 million hectare (ha) in Africa in 2014 with the bulk of production occurring on 10.6 million ha in West Africa, particularly in Nigeria. Maize (*Zea mays*) is ranked third after Cassava and Yam as the most cultivated crop in Nigeria (FAOSTAT, 2019). Nigeria is among the top twenty (20) maize producers in World and is ranked second after South Africa, with an estimated quantity of about 11.0 million tonnes produced in 2019 (FAOSTAT, 2019).

The first goal of the United Nation's based on Millennium Development Goal (MDGs) is poverty and hunger eradication and subsequently the second goal of the Sustainable Development Goals (SDGs) of Zero hunger were all targeted towards ending hunger, achieving food security, improving nutrition and promoting sustainable agriculture (United Nations, 2021).In September 2015, the United Nations (UN) ambitiously announced a goal of halving worldwide food waste and substantially reducing global food loss usually occasioned by postharvest losses by 2030 as part of its Sustainable Development Goals (SDG) agenda (Sheahan and Barrett, 2017; Meludu and Abolade, 2021).

Post-harvest losses just like the name implies are losses that occur after harvest that is between harvest and the moment of human consumption (Kiaya, 2014). They include on-farm losses, such as when grain is threshed, winnowed, and dried, as well as losses along the chain during transportation, storage, and processing. This problem poses serious implications for food security in the country as Nigeria is said to be losing about $9billion annually due to post harvest losses in the agricultural sector (Oba, 2020). Postharvest grain losses caused by insect pests during storage pose a major constraint to household food security.

According to Mobolade, Bunindro, Sahoo and Rajashekar (2019), it is estimated that 60–70% of food grains produced in developing nations are stored at home level in traditional structures either in threshed or unthreshed forms. In Nigeria, the prominent structures found in the three different climatic zones are; granaries, mud rhombus, thatched rhombus, platforms, cribs, earthen pots or baskets, domestic or indoor storage such as plastic containers, gourds, earthen pots and metal containers. Other storage structures include bags, which could be made of jute, hessian, polyethylene or plant fiber. In addition to the use of traditional storage structures, farmers use other coping strategies aimed at reducing these postharvest losses such as the use of traditional knowledge. These include the use of herbs such as the Mexican marigold and hot pepper in storage, selling grain soon after the harvest and cleaning or dusting the storage structure with wood ash or other inorganic pesticide thoroughly before depositing the produce to be stored.

In line with the need to provide the needed technical improvement in grain storage structures, the Nigerian Stored Products Research Institute (NSPRI) an organ of government saddled with the responsibility of reducing post-harvest losses in food crops through research and development of appropriate technologies have introduced some grain technologies. These grain technologies that have been disseminated to farmers include the hermetic storage (for household storage of grains), maize crib for the storage of maize on cob (unshelled maize),

improved warehouse storage and inert atmosphere storage (NSPRI guide, 2000; NSPRI Research News, 2011).

Hermetic bags are forms of storage structures designed to hold grains in an airtight environment. They were developed to help smallholder farmers in developing countries reduce postharvest losses due to insect infestation. The two-basic component of hermetic bags are the inner bags made of high-density transparent polyethylene bags which may be double or single depending on design and make. The transparent inner bag is purely designed to guarantee high impermeability of ambient atmosphere to create the desired sealed environment for a hermetic storage system (Jonfia-Essien, Navarro and Villers, 2010). The outer bag is not transparent in nature but made of woven polypropylene material basically designed for strength, due to handling problems and the weight of the grains that it will house (Baributsa and Ma. Cristine, 2020).

Storage insecticides are commonly used to control these weevils, but farmers that lack resources often do not have access to these insecticides and when they do, they may misuse them. Some in desperate bid to prevent or repel weevils from attacking the grains apply pesticides such as Sniper, Gammalin 20, "Otapiapia", and their likes. These are dangerous chemicals that are not fit for human consumption as they pose health hazards. This has left most stored grains in the tropics especially Nigeria, with huge amount of pesticide residue (Celestine, 2019; Mailafiya, Maina, Degri and Gadzama, 2014). European Union banned importation of food produce especially, beans from Nigeria in 2015 (Hussein, 2021; Juliana, 2021). The European Food Safety Council in a statement reiterated, that they were banned because most of the items contain as much as 0.3mg/kg to 4.6 mg/kg of pesticide residue against the maximum limit of 0.01mg/kg. Research carried out in 2015 by a non-governmental organization in Northern Nigeria which is the grain hub of Nigeria, showed that about 80% of all the grains sold in consumer markets across the region contained high level of pesticide/extraneous residue far more than the Maximum Residue Limit (MRL) and the Extraneous Residue Limit (ERL) as recommended by Codex Alimentarius Commission (Ojoye, 2017).

Substantial achievements have been made by both Governmental and Non-Government Organizations through the medium of The Agricultural Development Program (ADP), The United Nation's World Food Programme (WFP), The International Institute of Tropical Agriculture (IITA), and the Agriculture and Rural Development Secretariat Abuja (ARDS) to sensitize farmers especially grains and legume farmers in the Northern part of the country on the need for the use of hermetic storage bag technologies of which the benefits are enormous.

It is pertinent to mention that numerous researches have been conducted recently on Postharvest losses and the use of hermetic storage bag technology in the country among which are Benson *et al*., 2020, Abdullahi and Dandago (2021), Hamza, Aliyu, Umar and Ali (2021), Bolaji, Sanni, Damisa, Oladimeji and Kehinde (2019) and Otitodun*et al.*, (2021) just to mention a few. The majority of these studies focused on the negative impact of postharvest losses on food security and how effective the hermetic storage bag technology can be in mitigating this problem. This study therefore, aims to make lucid the level of adoption of this technology owing to the great level of awareness exercise already carried out by relevant agencies.

This study investigated the stage of adoption of hermetic storage bag technology among small holder cowpea and maize farmers in the Federal Capital Territory (FCT), Abuja. The result of this study would provide quantifiable evidence on the state of adoption of

hermeticstorage bag technologies. Moreover, it will help to determine factors that would motivate the wider adoption of this technology nationwide. It is against this background that the following specific objectives were considered:

1. describe the socioeconomic characteristics of the respondents;
2. identify the indigenous storage practices used by the farmers to control postharvest losses;
3. ascertain the sources of information available to the respondents as regards hermeticstorage bag technology, and
4. determine the stage of adoption of hermetic storage bag technology.

The hypothesis tested was;

H_o1: There is no significant relationship between the socioeconomic characteristics of the respondents and the adoption of hermetic storage bag technology.

Methodology

The research design of this study is descriptive in nature. This study made use of Survey research which enables the use of questionnaire in extracting information from the respondents.The study was conducted in The Federal Capital Territory (FCT), Abuja. The Federal Capital Territory (FCT) is located in the epicenter of Nigeria. Specifically, the territory is located north of the confluence of the great river Niger and Benue river. It is bordered by Kaduna State to the northeast, Niger State to the west and north, Nasarawa State to the east and south, and Kogi State to the southwest. On the global scale, it lies between latitudes 8°25′ and 9°20′ North of the equator and longitudes 6°45′ and 7°39′ East of Greenwich Meridian (Ejechi, Onu, Muogbo and Aboajah, 2016). The Federal Capital Territory has a landmass of approximately 7,315 km^2. It had a population of 1,408,239 persons according to 2006 population census but has grown to 3,564,126in 2016 according to the National Bureau of Statistics (NBS) projected population. The territory is currently made up of six Area Councils, namely Abaji, Abuja Municipal Area Council (AMAC), Bwari, Gwagwalada, Kuje and Kwali. The major crops grown in the area include maize (*Zea mays*) and sorghum (*Sorghum bicolor*), groundnuts (*Arachis hypogaea*), Cowpea (*Vigna unguiculata)* yam (*Discorea rotundata*), and miscellaneous crops such as okra, sweetpotato and garden egg (Ejechi, Onu, Muogbo and Aboajah, 2016).

Information sourced from the Agricultural Development Program FCT, Abuja revealed that due to continuous displacement of people as a result of insecurity from neighboring states, an exact figure cannot be ascertained. Abuja Municipal Area Council (AMAC) and Gwagwalada area council are two of the six area councils in the FCT that have been fairly stable. Collectively, they had an estimated population of about Three hundred and forty (340) farmers of which two hundred (200) were cowpea farmers and one hundred and Forty (140) maize farmers respectively. A multi-stage sampling procedure was employed by the researcher for the selection of the study target respondents. In the first stage, two area councils; Abuja Municipal Area Council (AMAC) and Gwagwalada area council were purposively selected because of their relative population stability and easy accessibility. In the second stage, a list of fifty (50) maize farmers and eighty (80) cowpea farmers were compiled in each selected area councils. From the list, 35 maize farmers each were randomly selected from AMAC and Gwagwalada area councils respectively. Also 50 cowpea farmers each were randomly selected from AMAC and Gwagwalada area councils respectively. This gave a sample size of one hundred and seventy (170) respondents for the study. The one hundred and seventy (170) farmers were made up ofseventy (70) maize farmers and one hundred (100) cowpea farmers. Data for this study were obtained from primary sources

(Smallholder Cowpea and Maize farmers). The Primary data were derived using a structured questionnaire/ interview schedule meticulously administered using the Kobo Collect Software.

The adoption level and socioeconomic variables were subjected to Logit regression in other to identify the determinants of hermetic storage bag technology adoption in the study. The significant values (p-value) obtained from the regression were used to test the significant level of H_o1. The model was explicitly stated thus:

$AHSBT = \beta_o + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \ldots\ldots\ldots\ldots\beta_nX_n + \varepsilon_i$ (Equation 1.0)

Where:

AHSBT = Adoption of Hermetic Storage Bag Technology

β_1-----β_n = Parameters to be estimated

β_o= Intercept

X1 = Age (years)

X2 = Household size (number of individual)

X3 = Farm size (hectares ha)

X4 = Farming experience (years)

X5 = Monthly income (₦)

X6 = Extension contact per annum (number of contact)

X7 = Sex (dummy: 1 = male, 0 = female)

X8 = Marital status (dummy: 1 = single, 2 = married, 3 = divorced, 4 = widowed)

X9 = Educational qualification (dummy: 1 = no formal education, 2 = primary education, 3 = secondary education, 4 = tertiary education)

ε_i = error terms

Results and Discussion

1.0 Socioeconomic Characteristics of the Farmers

The result presented revealed that majority (71%) of the farmers in the area are male, a greater proportion (80.59%) of the farmers were married. The mean age of the farmers was found to be 47years with a greater proportion (38.82%) of the farmers having secondary school education as their highest educational attainment. The average household size of the farmers was 7 persons with a mean farm size of 2.40 ha. The mean years of farming experience was found to be 18years. The mean monthly income was found to be ₦42, 902.94 while an average 17 extension contact per annum was recorded.

Table 1: Socioeconomic Characteristics of the Farmers

S/N	Variables	Observation	Mean	Std. Dev	Min	Max
1	Age	170	47.00	10.55	25	75
2	Household Size	170	7.00	2.88	1	16
3	Farm Size	170	2.40	2.04	0.5	15
4	Farming Experience	170	18.00	11.20	2	50
5	Monthly Income	170	42902.94	29419.09	5000	300000
6	Extension contact per annum	170	17.00	19.5	0	96

Source: Field survey data, July, 2022.

2.0 Indigenous storage practices used by the farmers to control postharvest losses;

Table 2: Distribution of Indigenous storage practices

S/N	Indigenous storage practices	Frequency (F)	Percentage (%)
1.	Jute sacks method	101	59.41
2.	Sun drying method	98	57.65
3.	Jerrycan method	77	45.29
4.	Chemical methods	72	42.35
5.	Small Silo method	64	37.65
6.	Mud Rhombus method	57	33.53
7.	Metal drums method	56	32.94
8.	Plastic bags method	56	32.94
9.	Application of wood ash	44	25.80
10.	Storage over fire place	43	25.29
11.	Baskets method	37	21.76
12.	Earthen pots method	32	18.82
13.	Botanical method	21	12.35
14.	Crib Method	14	8.24

Source: Field survey data, July, 2022.

Findings from the study revealed that a good number of the farmers still use the indigenous/ traditional systems of storage, with the use of jute sack and sun drying having the greatest percentages of usage with (59.41%) and (57.65%) respectively. This is in agreement with study conducted by Abubakar, Yohanna, Babuga, and Garba, (2020) where it was reported

that most small scale farmers rely on traditional ways of storing their produce thus incurring high post-harvest losses.

3.0 Sources of information available to the respondents as regards hermetic storage bag technology

Table 3 shows that information source from Agricultural extension officers ($\bar{x}$ = 3.40) ranked highest as the most accessed agricultural information source by the respondents. This could probably be due to the favourable extension approaches used by the extension officers to extend the hermetic storage bag technology/innovation to the farmers in the study area.Other Farmers ($\bar{x}$ = 2.86) and Agricultural Cooperative Societies ($\bar{x}$ = 2.68) were also identified among the major sources of information available to the respondents as regards hermetic storage bag technology. This result agrees with that of Uwandu, Thomas and Okoro (2018) that extension officers/ ADP were the main sources of agricultural information available to the farmers.

Table 3: Sources of information available to the farmers

S/n	Sources of information	Strongly Agree (4)	Agree (3)	Disagree (2)	Strongly Disagree (1)	Total score	Mean score ($\bar{x}$)	Decision
1	Agricultural Extension Officers	118(472)	14(42)	26(52)	12(12)	578	3.40	Agree
2	Agricultural Cooperative Societies	57(228)	42(126)	31(62)	40(40)	456	2.68	Agree
3	Radio	36(144)	31(93)	54(108)	49(49)	394	2.32	Disagree
4	Television	9(36)	32(96)	72(144)	57(57)	333	1.96	Disagree
5	Newspaper	5(20)	17(51)	85(170)	63(63)	304	1.79	Disagree
6	Posters	31(124)	16(48)	60(120)	63(63)	355	2.09	Disagree
7	Other Farmers	67(268)	45(135)	25(50)	33(33)	486	2.86	Agree

Source: Computed from the Field Survey Data, July, 2022.

4.0 Stages of adoption of hermetic storage bag

Figure 1 reveals that a greater majority 51.8% of the farmers had adopted the practice of using hermetic storage bags in the study area. This fairly high adoption percentage could be attributed to the effort from the Agricultural Development Project (ADP), Federal Ministry of Agriculture and Rural Development (FMARD), World Food Programme (WFP), International Institute for Tropical Agriculture (IITA) and Agriculture and Rural Development Secretariat (ARDS) to sensitize farmers on the need to adopt the technology.

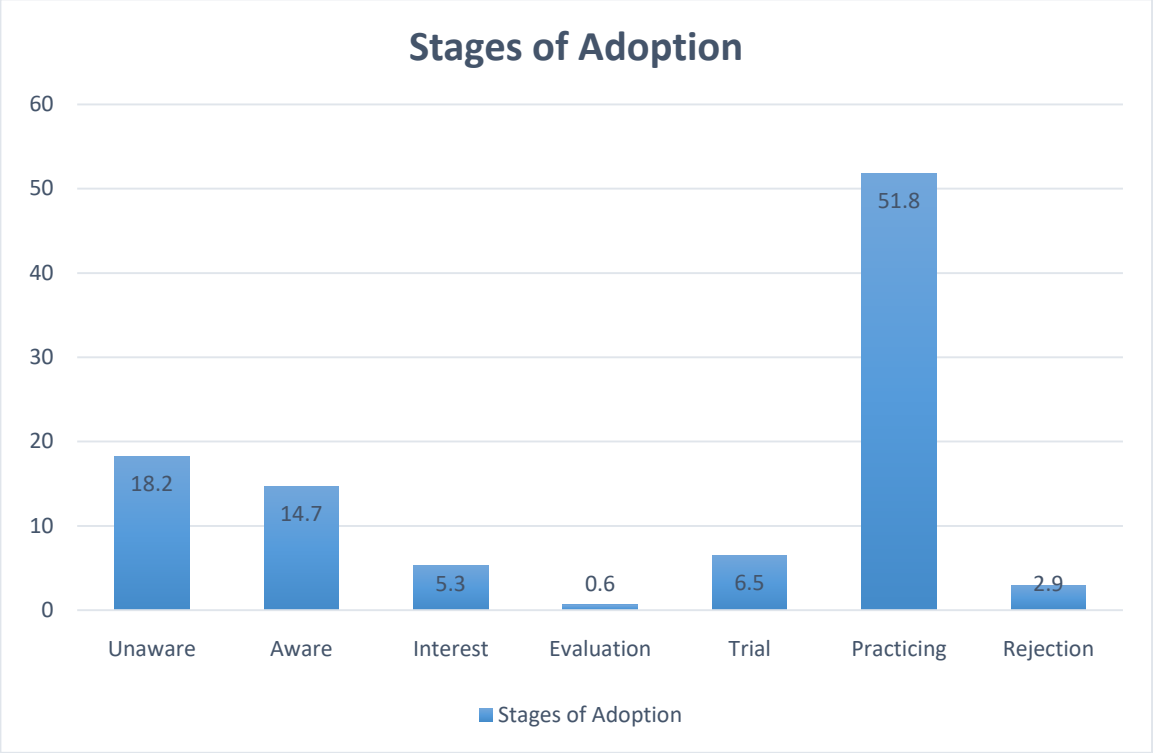

Figure 1: Stages of adoption of hermetic storage bag

5.0 Test of the Hypothesis

Hypothesis One (H_o1): There is no significant relationship between the socioeconomic characteristics of the respondents and the adoption of hermetic storage bag technology.

Table 4 and Table 5 present the result of Logit regression model and marginal effect analysis to investigate the relationship between the socioeconomic characteristics of the respondents and the adoption of hermetic storage bag technology.

Table 4: Logit regression result

Logistic regression				**Number of obs**	**=**	**170**
				LR chi2(9)	**=**	**49.48**
				Prob> chi2	**=**	**0.0000**
Log likelihood= -92.99087				**Pseudo R2**		**0.2101**
				=		

ADOPTION	**Coef.**	**Std. Err.**	**z**	**P> |z|**	**[95% Conf.**	**Interval]**
Age	0.0034455	0.0247597	0.14	0.889	-0.0450826	0.0519736
Household size	0.0731355	0.0995284	0.73	0.462	-0.1219366	0.2682076
Farm size	-0.1290992	0.1192511	-1.08	0.279	-0.3628271	0.1046288
Farming experience	0.0310198	0.021463	1.45	0.148	-0.0110469	0.0730866
Monthly income	0.0000298*	0.0000118	2.54	0.011	0.00000677	0.0000528
Extension contact per annum	0.0429225*	0.0165567	2.59	0.010	0.010472	0.075373
Sex	-1.434174**	0.46371	-3.09	0.002	-2.343029	-0.5253195
Marital status	-0.5607767	0.3429866	-1.63	0.102	-1.233018	0.1114648
Educational qualification	0.3589483*	0.1964087	1.83	0.068	-0.0260055	0.7439022
_cons	-1.430075	1.17932	-1.21	0.225	-3.7415	0.8813503

Source: Computed from the Field Survey Data, July, 2022.
* Significant at 10% and ** Significant at 5%

Table 5: Marginal effects result

Marginal effects

y = Pr(ADOPTION) (predict)
= .55187172

Variable	**dy/dx**	**Std. Err.**	**z**	**P>|z|**	**[95%**	**C.I.]**	**X**
Age	0.0008521	0.00612	0.14	0.889	-0.011152	0.012856	46.5412
Household size	0.0180871	0.02459	0.74	0.462	-0.03011	0.066284	6.61765
Farm size	-0.0319274	0.02952	-1.08	0.280	-0.089793	0.025938	2.42941
Farming experience	0.0076715	0.00532	1.44	0.149	-0.002747	0.01809	18.35
Monthly income	0.00000737	0.00000	2.55	0.011	0.0000017	0.000013	42902.9
Extension contact per annum	0.0106151	0.00405	2.62	0.009	0.002676	0.018555	16.9647
Sex	-0.3253611	0.09111	-3.57	0.000	-0.503926	-0.146796	0.705882
Marital status	-0.1386853	0.08495	-1.63	0.103	-0.305189	0.027819	2.10588
Educational qualification	0.0887713	0.04856	1.83	0.068	-0.006403	0.183945	2.57647

The result of the logit regression done to ascertain the relationship between socioeconomic characteristics and the adoption of hermetic storage bag technology using STATA 13.0 recorded a Log likelihood of -92.99087. The higher the negative value of Log-likelihood, the better the result to explain the model. The Likelihood Ratio (LR chi2) of 49.48 at

probability>chi2 0.0000 is an indication that the model was fit to explain the socioeconomic relationship with adoption. The regression was predicted as follows;

Adoption = -1.43008 + $0.00345X_1$+ $0.07314X_2$- $0.1291X_3$ + $0.03102X_4$ + $0.00003X_5$ + $0.04292X_6$- $1.43417X_7$- $0.56078X_8$ + $0.35895X_9$

The coefficient of age, household size, farm size,farming experience and marital status were neither significant at 10%, 5% nor 1% level of probability. On the other hand;

The coefficient of monthly income (X_5) was positive and significant at 10% level of probability. The marginal effect shows that with one naira increase in monthly incomethe choice of adoption of hermetic storage bag technology has the likelihood of increasing by (0.000737%) ceteris paribus. Farmers with higher monthly income may have more resources and a higher need of good storage methods and, thus, are more likely to adopt the hermetic storage bag technology as this was in tune with Mekonen and Wubetie (2021).

The coefficient of extension contact per annum (X_6) was positive and significant at 10% level of probability. The marginal effect shows that with one unit increase in extension contact per annum, the choice of adoption of hermetic storage bag technology has the likelihood of increasing by (1.06%) ceteris paribus. This result corroborates the findings of Wongnaa, Awunyo-Vitor and Bakang, (2018).

The coefficient of sex (X_7) was negative and statistically significance at 5% significant level.The results of the model revealed that female farmers were (32.54%) more probable to adopt the use of hermetic storage bag technology. This could be attributed to the fact that storage activities in northern Nigeria can be said to resonate more with the female gender according to Murtala, et al., (2021)

The coefficient of educational qualification (X_9) was positive and significant at 10% level of probability. The marginal effect shows that with one step increase in educational qualification the choice of adoption of hermetic storage bag technology has the likelihood of increasing by (8.88%) ceteris paribus. Educational levels increase the ability to obtain, process and use information relevant to the adoption of a new technology Ali, Awuni andDanso-Abbeam, (2018). The result corroborates with that of Olorunfemi, (2018) that education is a helpful tool for farmers in analyzing choices and making decisions about forecasts of the anticipated benefits of adopting technologies.

Conclusion

An averagely good number of the farmers adopted the use of the hermetic storage bag technology. The adoption numbers are not all that fantastic considering the percentage of farmers still unaware such a technology exists. The efforts of the agricultural extension officers in collaboration with other agencies and Nongovernmental organizations should play a pivotal role in facilitating the rate of adoption.

Based on the findings, these following recommendations were made;

i. Funding agencies should be more active in on the spot monitoring and evaluation of their projects. It's not enough to dole out fund and rely on reports which in most cases are doctored.
ii. Agricultural Development Programme (ADP) should target more youth who are still willing to adopt agricultural innovations/packages that can help to both improve and increase agricultural production.

iii. As part of measures to making more farmers and grain merchants use the hermetic storage bag technology, it is recommended that the government at all levels make it mandatory for all grains supplied to its institutions and organizations, be it schools, prisons, camps, orphanages and canteens be devoid of pesticides and other harmful storage chemicals.

iv. Rural farmers are key beneficiaries of most agricultural projects therefore, it's important that the Government and project implementing agencies make plans to enroll local farmers into adult education. This will not only help them to learn and abide by some simple instructions and guidelines but will also increase the ease of adopting a new technology.

v. The research institutes/universities should also carry out extension programmes, training on postharvest technologies for farmers' local agro processors at the rural areas.

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