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Adoption and Profitability of the Purdue Improved Crop Storage Technology for Grain Storage in the South-Central Regions of Niger

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Abstract: Cowpea is a food security crop and a main source of income for farmers in Niger. However, postharvest storage remains a major challenge due to insect pest attacks. Since 2008, the Purdue Improved Crop Storage (PICS) bags were disseminated in Niger to reduce storage losses. This study was conducted to assess the adoption of the PICS technology in the Dosso, Maradi, and Zinder regions of Niger. We interviewed 600 households selected from villages that did and did not benefit from PICS extension activities. A logit regression model was used to assess the decision of farmers to adopt the PICS technology. The overall adoption of the PICS bags among farmers was 48.4%. PICS adoption was 69.7% in Dosso, 41.3% in Zinder, and 31.2% in Maradi. Farmers who attended PICS training were 5 times more likely to adopt the technology than those who did not. Variables that affected the adoption of the PICS technology included the region, participation in PICS training, and information source. Beyond cowpea, PICS bags were used to store a variety of crops including Bambara nuts, hibiscus seeds, peanuts, millet, and sorghum. Storing 100 kg of cowpea in a PICS bag generated a cash flow of $70.38 per respondent and a net return of $21.50. Revenues generated from sales of cowpea stored in PICS bags were mostly used for health expenditures and to purchase agricultural inputs. Results of this study demonstrate that pest management technologies such as PICS bags can also contribute to improving the livelihood of family farms.

Keywords: cowpea storage; pests; hermetic bags; technology scale-up; smallholder farmers

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1. Introduction

Protecting crops against pest damage is one way to meet food demand that requires relatively modest investments compared to increasing crop production [1]. Cowpeas are susceptible to the insect pest, *Callosobruchus maculatus* (F.), during storage. This pest can cause losses of over 30% after only four months of storage [2,3]. Farmers have always complained that postharvest storage is one of the major constraints that hamper investments in cowpea production [4]. Storage losses, in part, force farmers to sell their cowpea when prices are low at harvest [5]. Farmers use a variety of storage protection methods including chemicals, botanicals, and traditional methods such as ash [2]. Most of these storage methods are either expensive, ineffective or pose health hazards to consumers and the environment due to their toxicity.

Hermetic storage technologies provide alternatives to chemical and traditional methods. These methods include hermetic bags such as the Purdue Improved Crop Storage (PICS) bags. PICS bags consist of two layers of high-density polyethylene (HDPE) plastic that are fitted inside a woven polypropylene bag. The bag works by restricting the movement of air from the outside to the inside of the container. Once the bag is filled

with cowpea, the small population of insects already on the grain consumes the remaining oxygen inside the container leading to quiescence and death [6,7]. Early versions of the PICS bags were developed about 30 years ago by Purdue University in collaboration with research institutions in West and Central Africa [8].

Beginning in 2007, PICS bags were disseminated in 10 countries in West and Central Africa to reduce storage losses on cowpea in the region [5]. Through pilot activities, PICS bags were introduced to two hundred villages in Niger and Burkina Faso (100 communities in each country). During scale-up activities in Niger, the PICS bags were disseminated to farmers in more than 5000 villages by the extension services of the Ministry of Agriculture and Livestock in collaboration with the Niger National Institute of Agricultural Research (INRAN) and World Vision International [5,9]. In the mid-2010s, the PICS bags were commercialized in several other countries in sub-Saharan Africa for the storage of crops other than cowpea including maize, beans, sorghum, rice, and pigeon peas [10]. Niger was not part of this effort but benefited from projects led by local and international Non-Governmental Organizations (NGOs).

While disseminating PICS bags, efforts were made to develop the supply chain by working with the private sector (plastic manufacturer and input distributors) to improve the availability of the technology among farmers in rural areas. The PICS bags sold in Niger have been manufactured in Kano, Nigeria, and distributed in the country through a network of distributors and vendors [11]. To date, more than 1.5 million PICS bags have been sold to the government, projects, and smallholder farmers in Niger. For several years, the PICS supply chain in Niger was managed by a national distributor based in Dosso town who had a licensing agreement with Purdue University [11]. In recent years, the supply chain has moved toward a flat distribution system where most vendors get their bags from the manufacturers and distributors of PICS bags in Nigeria through formal and informal networks.

Despite an increase in the demand for the PICS technology, unavailability has been a major challenge in rural areas. An adoption study conducted in ten countries in West and Central Africa found that 18% of farmers were using PICS bags for cowpea storage [12]. Adoption of the PICS bags varied by country and within each country. Research conducted in Niger in 2010 showed significant variation in the adoption of the PICS technology among several regions, varying from 38% in Dosso to only 7% in Maradi, Zinder, and Tahoua [13]. Both the 2010 and 2012 studies pointed out that the supply chain was the major challenge in improving the availability and adoption of PICS bags in rural areas [12,13]. A decade after hermetic triple bags were disseminated in Niger, this study aimed to assess the adoption of the PICS technology among farmers. This information will be useful to development partners, donors, and the government interested in continuing to promote hermetic storage to improve food security and increase the income of farmers.

2. Materials and Methods

2.1. Study Sites and Implementation of the Survey

This study was conducted in November 2018 in three main cowpea-producing regions of Niger including Dosso, Maradi, and Zinder. These three regions represent 64.46% of the country's cowpea production [14]. The study was implemented in the following departments: Dosso and Doutchi in Dosso, Madarounfa and Mayahi in Maradi, and Magaria and Mirriah in Zinder. To conduct the survey, 6250 agricultural households were identified, of which 600 households (about 10%) were randomly selected for the study. In each region, we selected 20 villages including 12 that received PICS extension activities (PICS villages) and eight villages that did not (non-PICS villages). These villages were selected with the help of extension agents from the local agriculture department office. During the selection of non-PICS villages, we cross-checked with extension agents to make sure they did not benefit from any other projects promoting PICS technology. We interviewed ten respondents from each village (each representing a household) from a list of names provided by the head of the village. The choice of 10 households was deemed

satisfactory for the comparison analyzes but also due to limited resources for the study. These surveyed households were chosen using the simple random draw after having numbered all households from 1 to *N* for each village. The interviews were conducted face-to-face using enumerators who spoke local languages.

2.2. Empirical and Conceptual Models

Despite efforts to improve cowpea productivity, pre-and post-harvest losses remain major challenges, resulting in food insecurity and loss of income among smallholder farmers [15]. Consequently, it is important to identify the main constraints that could hinder the adoption of storage technology with the potential to help postharvest losses. This study contributes to research and extension efforts to disseminate agricultural technologies in south-central Niger and the whole country. Improving agricultural productivity through adoption will result in economic and social impact [16]. Farmers who adopt a new technology must evaluate whether it is profitable. The profitability of a storage method will depend on several factors including the grain stored, price seasonality, and the cost of storage protection [17]. Therefore, it is important to understand how various factors affect the adoption and profitability of storage technologies.

We chose the Logit model often used in technology adoption studies [18,19]. The binary logit model was used to determine the socioeconomic variables influencing the adoption of "PICS" technology (Table 1). The chosen reference situation is one where the dependent variable "adoption" is dichotomous-takes the value one (1) if the farmer adopts PICS technology, and zero (0), otherwise. We assessed whether large-scale extension activities facilitated the adoption of the PICS technology. Socio-economics variables such as gender, age, level of education, access to credit, household size, training, information source, membership to farmers' organizations, etc. were used in the logit model. Other variables that provide information on the characteristics of the study areas such as proximity to certain infrastructures related to the study (e.g., proximity to the point of sale of PICS bags) was part of this study.

Table 1. Description of variables used in the logit regression model.

Variables	Description	Expected Effects
	Dependent variables	
Adoption	1 if a respondent adopted PICS and zero if not.	
	Explanatory variables	
Region	1 if a farmer is from Dosso and zero otherwise.	+
Village type	1 if a village received PICS activities and zero otherwise.	+
Gender	1 if a respondent is male and zero for a woman.	+
Age	Continuous variable indicating the age of the respondent.	+
Marital status	1 if a respondent is married and zero otherwise.	+
Education	1 if a respondent is literate (know how to read and write) and zero otherwise.	+
Household size	Continuous variable indicating the number of people in the household.	+
Association	1 if a respondent is a member of farmers' group and zero otherwise.	+
Information source	1 if a respondent received information on PICS from extension agents and zero otherwise.	+
PICS participation	1 if a respondent attended a training on the use of the PICS technology and zero otherwise.	+
Distance to the sale point	1 if a respondent's village is < 10 km to sale point of PICS bags and zero otherwise.	+
Access to credit	1 if a respondent accessed a loan from microfinance banks and zero otherwise.	+

2.3. Data Collection and Analysis

Data was collected using Android devices and responses were recorded using KoboCollect (Harvard Humanitarian Initiative, Cambridge, MA, USA). Data collected included (i) Socio-economic characteristics of the respondents; (ii) Number of farmers who have used and continue to use the PICS bags; (iii) Crops stored with the technology; (iv) Quantity

of grain stored by crop; (v) Price of grain at harvest and during the lean season; and (vi) Use of income generated from stored grain. After the survey, data was downloaded as a Microsoft EXCEL sheet and then cleaned before analysis. Data analyzes were carried out using SPSS 26.0 (IBM Corp., New York, NY, USA) simple descriptive statistics, analysis of variances, and multivariate logistic regression in which the dependent variable, log odds using the model:

$$Y = \beta 0 + \beta 1 \text{ Region} + \beta 2 \text{ Village type} + \beta 3 \text{ Gender} + \beta 4 \text{ Age} + \beta 5 \text{ Marital status} + \beta 5 \text{ Education} + \beta 6 \text{ Household size} + \beta 7 \text{ Association to farmers' groups} + \beta 8 \text{ Information Source} + \beta 9 \text{ PICS participation} + \beta 10 \text{ Distance to the sale point} + \beta 11 \text{ Access to credit} + ei$$

where $\beta 0$ is the constant term; βi the coefficients to be estimated, and ei the error terms.

The variables listed as year of experience and family labor were not used in the logit model because they were highly correlated to age and family size, respectively. Several independent variables were chosen based on the literature (education level, membership of farmers' organization, training on the PICS technology, gender, access to credit, age, marital status) and the storage intervention (contact with extension service, distance to the point of sale of PICS bag).

We assessed the potential return on investment (ROI) of storing cowpea in PICS bags for six months by comparing grain prices at harvest and during the lean season. The price of cowpea was provided by the respondents during the survey. Retail prices of a 100 kg PICS bag were obtained from each interviewee and used to determine the average price in each region. We performed the ROI analyses based on approaches used in previous studies [20,21].

3. Results

3.1. Characteristics of Respondents

The average age of the respondents was 47 years (±14 years) (Table 2). About 99% of respondents had agriculture as their main activity with an average of 27 years (±14 years) of experience. Only 31.3% of respondents were literate and 98% of farmers were married. An average household had 9 people of which about 4 were involved in farming activities. About 43% of the respondents were members of farmers' groups and 13.3% of farmers had access to credit from microfinance banks.

Table 2. Characteristics of respondents to the survey conducted in Dosso, Maradi, and Zinder regions of Niger.

Characteristics	Dosso (n = 200)	Maradi (n = 200)	Zinder (n = 200)	Average (%)	ANOVA Data	
	Respondents (Mean * ± Standard Error of Mean)					
Age (years)	51 ± 1b	44 ± 1a	46 ± 12a	47 ± 14	F = 15.30; df = 2/600; $p < 0.0001$	
Household size (people)	9 ± 6ab	8 ± 5a	10 ± 6b	9 ± 6	F = 3.72; df = 2/600; $p = 0.025$	
Experience in agriculture (years)	32 ± 2b	24 ± 14a	27 ± 13a	27 ± 14	F = 17.36; df = 2/600; $p < 0.0001$	
Family labor (people)	5 ± 3b	3 ± 2a	4 ± 2b	4 ± 2	F = 14.38; df = 2/600; $p < 0.0001$	
	Proportion of respondents (%)				$\chi 2$	p-value
Education, % literate	21.6	50	24.8	31.3	43.95	<0.0001
Association, % member	33.9	60.2	35.9	42.6	34.04	<0.0001
Access to credit, % receiving loan	15.1	16.7	8.3	13.3	7.02	0.05

* Means in the same column followed by the same letter are not significantly different (LSD, 5%).

3.2. PICS Technology Adoption

The overall adoption rate of the PICS bags among farmers was 48.4%. Across the three regions, no significant differences were observed between adopters and non-adopters for all variables except association to farmers' groups ($p = 0.002$), PICS participation ($p < 0$), and access to credit ($p = 0.005$). Depending on the region, the adoption rates of the PICS bag ranged from 31.2 to 69.7% (Table 3). The adoption was higher among men, married

individuals, farmers who attended PICS training, in PICS villages (received PICS training activities), and in the Dosso region. The adoption of PICS bags was twice as high in the Dosso region compared to the Maradi region. Respondents who attended PICS training had a higher adoption of PICS bags (5 times more) compared to those who did not participate in PICS training. Households in villages that received PICS demonstrations had a higher adoption compared to those with no training (a gap of 13.4%). Farmers using PICS bags purchased them through various channels—78.6% from markets, 11.5% from shops, and 8.2% from roaming vendors (data not shown). Among those buying PICS bags from markets—100% in Dosso, 87.0% Zinder, 58.3% in Maradi. Most farmers (72.1%) had to travel less than 10 km to purchase PICS bags. Farmers purchased 1 to 300 PICS bags, with a median of 3 bags. Half (50%) and three-quarters (75%) of the respondents bought 3 and 11 PICS bags or less, respectively (data not shown). On average, farmers in the Dosso region purchased more bags (20 PICS bags) than those in Maradi (7 PICS bags) and Zinder (7 PICS bags) regions.

Table 3. Adoption of the PICS technology by farmers (%) in Dosso, Maradi, and Zinder regions of Niger.

Parameters	Variable	Adoption Rate (%)	χ2	Significance
Regions	Dosso	69.7	65.977	***
	Maradi	31.2		
	Zinder	41.3		
Village type	PICS	53.8	9.999	**
	Non-PICS	40.4		
Gender	Men	50.9	4.001	**
	Women	42		
Marital status	Married	48.7	1.107	ns
	Single	33.3		
Education level	Illiterate	49.2	0.346	ns
	Literate	46.6		
PICS participation	Trained	70.8	193.18	***
	Not trained	13.1		

, * difference among regions significant at levels 0.01, and 0.001, respectively; ns: no significant difference.

3.3. Determinants of PICS Bag Adoption

The PICS bag adoption Logit model estimation results are shown in Table 4. It is a model that integrates qualitative and quantitative variables. Of all the explanatory variables tested, three significantly explain the adoption of the PICS technology. These variables are the region, participation in PICS training, and information source.

3.4. Crop and Quantity Stored in PICS Bags

Farmers used the PICS bags to store a variety of crops but most predominantly cowpea (Table 5). A high proportion of farmers in Dosso used PICS bags to store crops other than cowpea including Bambara nut and hibiscus seed. More farmers in the Dosso region stored Bambara nut in PICS bags than those in the Zinder and Maradi regions. Groundnut, millet, and sorghum were stored in PICS bags by a relatively low number of farmers; mostly in Zinder and Maradi. Almost all respondents (98.3%) were satisfied with the performance of the PICS bags for cowpea storage. Cowpea was stored in large quantities in the PICS bags compared to Bambara nut, hibiscus seed, and groundnuts. There was no significant difference ($p < 0.05$) among regions, between PICS adopters and non-adopters, and between PICS and non-PICS villages in terms of quantity of cowpea stored. On average, farmers stored their cowpea in PICS bags for 7 months. Most farmers (90%) stored their cowpea for up to 8 months (data not shown).

Table 4. Factors determining the adoption of PICS Bags by farmers in Dosso, Maradi, and Zinder regions of Niger.

Variables	Coefficient	Wald	*p*-Value
Region	5.802	46.399	<0.0001
Village type	1.345	1.698	0.193
Gender	1.081	0.068	0.795
Age	0.987	2.279	0.131
Marital status	0.723	0.124	0.725
Education	0.768	1.185	0.276
Household size	0.992	0.122	0.727
Association to farmers' groups	1.525	2.671	0.102
Information Source	2.195	6.790	0.009
PICS participation	8.591	66.986	<0.0001
Distance to the sale point	1.041	0.026	0.873
Access to credit	1.344	0.765	0.382
Constant	0.249	1.872	0.171

Table 5. Proportion of farmers who stored different crops and quantities stored using PICS Bags in Dosso, Maradi, and Zinder regions of Niger.

Crop	Respondents Storing (% Farmers)					
	Dosso	Maradi	Zinder	Average	$\chi 2$	*p*-Value
Cowpea	73.7	72.7	84.4	76.6	4.6	ns
Bambara nut	56.6	3	5.2	31.5	106.6	***
Hibiscus seed	35.4	16.7	3.1	22.6	38.7	***
Groundnut	8	6.1	16.7	10.1	6.6	**
Millet	5.7	18.2	17.7	11.6	12.2	**
Sorghum	0	6.1	17.7	6.2	33.3	***
Crop	**Quantity Stored** (Mean [&] ± Standard Error of Mean, kg)					
	Dosso	Maradi	Zinder	Average	ANOVA data	
Cowpea	479.8 ± 103.5a	224.4 ± 91.9a	238.2 ± 57.5a	328.1 ± 51.1a	F = 2.81; df = 2/600; p = 0.06	
Bambara nut	93.6 ± 21.1a	0b	0b	36.2 ± 8.41a	F = 19.65; df= 2/600; p < 0.0001	
Hibiscus seed	54.4 ± 13.7a	12.4 ± 7.8a	0b	24.3 ± 5.8a	F = 11.94; df = 2/600; p < 0.0001	
Groundnut	21.9 ± 8.1a	2.3 ± 2.3a	8.4 ± 3.3a	12 ± 3.4a	F = 4.26; df = 2/600; p = 0.015	

,* difference among regions significant at levels 0.01, and 0.001, respectively; ns: no significant difference. [&] Means in the same column followed by the same letter are not significantly different (LSD, 5%).

3.5. Estimate of Revenues Generated by Storing Cowpea in PICS Bags and Their Use

The PICS technology promoted in Niger for more than a decade shows a positive return on investment (ROI) when grain is stored in PICS bags for several months (Table 6). The difference in prices during the lean and harvest seasons shows positive returns on investments varying from 47.7% in Zinder to 61.5% in Dosso. The overall net return was CFA Francs 12,146 across the three regions.

Table 6. Estimates of return on investment (ROI) when farmers stored cowpea using a 100kg PICS bag for 6 months in Dosso, Maradi, and Zinder regions of Niger.

Regions	Price (FCFA */100 kg bag)		FCFA				Percent
	Harvest	Lean Season	Gross Margin **	PICS Bag	OCC ***	Net Gain	ROI ****
Dosso	19,900	36,400	16,500	1100	3238	12,162	57.9
Maradi	22,300	41,400	19,100	1100	3608	14,392	61.5
Zinder	22,500	38,500	16,000	1100	3639	11,261	47.7
Average	21,300	38,000	16,700	1100	3454	12,146	54.2

* FCFA: Francs Communauté Financière d'Afrique; as of 17 October 2018 (US $1 = 566 FCFA). ** Gross margin is the difference between the price at the lean season and the price at harvest. *** OCC: Opportunity cost of capital is estimated at 2.57% for 6 months (based on commercial bank interest rates on loans in 2018). **** ROI: Return on investment. Estimates are conservative because the cost of PICS bags is for one-season use (we know bags can be used for 2 or 3 years).

The income generated by selling grain stored in PICS was mostly used for household needs and investment in agriculture production (Table 7). Most respondents used the revenues for medical care (67.4%), purchase of agricultural inputs (41.8%), and farm equipment (27.5%). In the Dosso region, about two-fifths and one-third of farmers spent their revenues on ceremonies (e.g., weddings, birthdays, burials, etc.) and education, respectively.

Table 7. Farmer' expenditure of revenues generated by sales of grain stored using PICS Bags in Dosso, Maradi, and Zinder regions of Niger.

Parameters	Dosso	Maradi	Zinder	% Average	$\chi 2$	*p*-Value
Schooling	31.6	14.3	16.9	22.2	17.823	***
Health	71.4	60.3	67.8	67.4	4.36	ns
Agricultural inputs	42.2	43.7	40.1	41.8	0.4	ns
Agricultural Equipment	29.6	22.2	28.8	27.5	2.27	ns
Purchase of livestock	21.8	10.3	17.5	17.5	7.2	**
Ceremonies	40.3	15.9	29.4	30.5	22.15	***

, * difference among regions significant at levels 0.01, and 0.001, respectively; ns: no significant difference.

4. Discussion

4.1. Adoption of the PICS Technology

Since 2008, the PICS technology was disseminated in West and Central Africa primarily for cowpea storage by extension services and sold to farmers through private sector distribution networks. Over the years, there have been significant increases in the adoption of the PICS bags. After a decade, the overall adoption of 48.4% in 2018 was about 2.7 times that reported in 2012 in Niger [12]. There were quite high adoption rates in Dosso, Maradi, and Zinder compared to the 2010 adoption rates which were 38% in the Dosso-Tillabery area and 7% in the Maradi-Zinder-Tahoua area [13]. Unlike the 2012 survey, our results showed a significant increase in adoption of PICS bags in non-PICS villages (40.4%) though statistically lower than in PICS villages with a gap of about 13.4% [12]. This narrowing gap may be explained by increased awareness of the existence of the technology from PICS to no-PICS villages. However, the proportion of farmers using hermetic bags in these non-PICS villages is far less; 5 times lower than that in PICS villages. This indicates that there is still a need for more training and capacity building among farmers in these non-PICS villages.

The overall adoption of the PICS bags, mostly in PICS villages and by farmers within them, has increased over time due to continued awareness and efforts by the private sector to improve availability of the technology in rural areas. About half of farmers using PICS bags were members of farmers' groups. Farmers play an important role in disseminating information on hermetic bags to their peers [20]. The density of the distribution network and the distance from the village to PICS bag retail points are important factors that affect the adoption of the technology in Niger [13]. The availability of PICS bags has significantly improved since 2010 as the majority of farmers purchased them from rural markets. PICS bags being sold in more markets means improvements in availability of the technology in rural areas. Local markets may be the best place to retail PICS bags since most farmers attend them to sell their produce (may have the cash to spend on inputs).

The logistic regression results show that region, participation in PICS training, and source of information were predictors of adoption of the PICS technology ($p < 0.05$). Among all these factors, the variables region and participation in PICS training had the greatest impact. The differences in adoption among the regions can be explained by several factors including cowpea production, the intensity of extension efforts in disseminating PICS bags, and the level of development of the supply chain to make the technology available to farmers in rural areas. Dosso may have had the highest adoption rate because of high cowpea production, more demonstrations, and a well-developed distribution network of vendors who sell PICS bags in local markets [11,14,22]. Also, Dosso is where the national distributor of PICS bags in Niger is based; hence, supply and distribution activities were

more prominent compared to other regions. Studies have shown that attending PICS awareness building or demonstration increases the likelihood of a farmer purchasing the technology [23,24]. Having an extension agent as a source of information significantly increases the adoption of PICS bags [25]. This demonstrates the importance of training and awareness creation for the diffusion of technologies among smallholder farmers [5,25,26].

Unlike some other studies, being from a village that received PICS training, membership to farmers groups, size of the household, contact with extension agents, and access to credit did not influence the adoption of the PICS technology [12,25,27,28]. It appears that the importance of PICS village demonstration and contact with extension in influencing the adoption of the technology has waned over time. With such a low level of literacy (about a third of respondents), it is interesting that we did not observe an effect of education on the adoption of the PICS bags. This might be explained by the simplicity of the technology-easy PICS program for farmers. The distance from villages to point of sales was not statistically significant, which may suggest improvements in the availability of PICS bags among farmers. This is corroborated by the high number of farmers (>75%) who buy their bags in local markets.

4.2. Crop Stored and Quantity Stored

PICS bags were originally developed and disseminated for cowpea storage but later found to be effective in storing various dried commodities including legume and cereal crops, and processed foodstuffs [29]. Though farmers were aware that they could store a variety of crops, more than three-quarters of them chose to store cowpea. The proportion of farmers storing cowpea was consistent across the three regions; demonstrating the importance of this crop at the household level. Cowpea had the largest quantity stored—9, 14, and 27 times that of Bambara nuts, hibiscus seed, and groundnut, respectively. This is not surprising as cowpea is an important food security and cash crop in Niger [30,31]. These results demonstrate that cowpea will continue to remain the most important crop that drives the commercialization (demand) of hermetic bags in Niger. All other crops stored in PICS bags are known to be susceptible to insect pests and the technology has proven to be effective in their preservation [32–34]. Most secondary commodities (crops other than cowpea; i.e., Bambara nuts and hibiscus seeds) stored in PICS bags are primarily grown by women; and processed for home consumption and/or sold to generate income [25,35].

4.3. Storage Income Generation and Use

Hermetic bags have significant monetary benefits beyond improving food security by reducing insect infestation. Studies have shown that cowpea stored in a 100 kg PICS bag provided net benefits of $10.81 to $26.58 in West and Central Africa, and up to $24 in East Africa [12,20,25]. Net cash flow deriving from storing other crops such as maize in PICS has been relatively low; varying from $5 to $19 in East Africa [20,27,36]. This study showed a cash flow of about $70.38 per respondent and a net return of $21.50 per 100 kg of cowpea stored in a PICS bag. This cash flow is similar to the $71.65 observed in Niger in 2012 [12]. The estimated average return on investment (ROI) is 54.2% which demonstrates that storage is a profitable endeavor. This ROI is above the 48% reported for cowpea stored in PICS bags in Nigeria [37]. PICS, similar to many other new agricultural technologies, has a positive and significant impact on reducing rural poverty by increasing the income of farm households [38,39]. Farmers invest in PICS bags because the financial benefits sufficiently outweigh the acquisition costs [40]. Income generated from storing cowpea in PICS bags was mainly invested in family health care, the purchase of agricultural inputs, and family events such as weddings, birthdays, and funerals. Beyond reducing postharvest losses due to insect attacks, the PICS bags are helping to bridge the poverty gap and improving the livelihoods of smallholder farmers.

5. Conclusions

This study shows that the adoption of PICS bags almost doubled 10 years after the technology was introduced in Niger. Several variables explained the adoption of the PICS technology including the region, participation in PICS training, and information source. Despite an increase in adoption compared to 2010 and 2012, the number of farmers using the technology in non-PICS villages is still low. Maradi recorded the lowest adoption rate of the PICS bag compared to other regions. Thus, there is a need to increase awareness and training of farmers in Maradi and in non-PICS villages across the three regions. Cowpea is still the major crop driving the adoption of the PICS technology and would continue to drive its commercialization. Storing cowpea in PICS bags allowed farmers to earn additional income used to address farming and other household needs. This study highlights the importance of disseminating and increasing the adoption of agricultural technologies to improve rural livelihoods.

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Conflicts of Interest: The authors declare the following financial interests/personal relationships, which may be considered as potential competing interests: D.B. is a co-founder of PICS Global Inc., a social enterprise that commercializes postharvest technologies (including PICS bags) to small-holder farmers around the world and hence declares a conflict of interest. The other authors declare no conflict of interest. The funder (Bill and Melinda Gates Foundation) had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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