

Impact of the Purdue Improved Cowpea Storage Technology on the Income of Cowpea Farmers in North Central Nigeria

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Abstract - The objective of this study was to determine the potential impact of Purdue improved cowpea storage (PICS) technology on the income of users in north central states of Nigeria. A multi-stage sampling procedure involved selection of 3 Local Government Areas (LGAs) each from 18 senatorial districts of six states, 108 villages. Thereafter 2,220 cowpea PICS stakeholders comprising 1,240 farmers and 960 traders were randomly selected by balloting technique. The study used primary data and structured questionnaire to interview users and non-users of PICS bag. Descriptive statistics, double difference estimator, propensity score matching (PSM) and logic model were used to analyze the data. The result showed a positive mean difference of ₦1,205.12 per 50 kg bag ($p < 0.01$) in income between users and non-users before and after adoption of PICS technology. The result of logit model revealed that variables age, education status, employment status, income and quantity of cowpea used in the analysis were significant at different level of probability. The PSM adjusted with constant coefficient value of 1.000 was statistically significant at 1% level. Thus, the PICS technology was a better strategy adopted by farmers/traders to increase their income and improve their standard of living. Since majority of farmers and traders are young and educated, trainings, workshops and sensitization should be encouraged. This can be effectively done through Agricultural Development Programmes (ADP), Non-Governmental Organizations (NGOs) and attending farmer's stakeholders meeting for sensitization.

Keywords - Cowpea, impact, Propensity Score Matching (PSM), Purdue.

1 INTRODUCTION

Cowpea (*vigna unguiculata*) is the most economically and nutritionally important indigenous African grain legume, grown by millions of small-scale farmers (Baribitsa *et al.*, 2012). It serves as alternatives and supplements to animal proteins, particularly in parts of the world where there is paucity of animal proteins due to socio economic constraints. Cowpea provides protein and thus prevents nutritional diseases, which can also lead to economic gains.

However, the post-harvest grain storage is a recurrent constraint for increased cowpea production in Africa because of the risk of losses by bruchids (Nkunda, 2018). This is often identified as the key challenge for small-scale cowpea growers. Cowpea grains are severely damaged during storage by insect pests mostly bruchids (cowpea beetles). This has significantly reduced the quality and quantity of cowpea, resulting in cuts in the food supply for millions of households in Nigeria and north central states in particular. The early disposal of cowpea products (grains), has greatly affected farmers gain margin. This has affected cowpea trade and has severe implications on the economy. Above all, postharvest food losses contribute greatly to food, nutrition, and income insecurity in sub-Saharan Africa (Owach *et al.*, 2017). For this reason, reliable preservative measure(s) need to be sort for. Many farmers sell cowpea grain at low prices during harvest time due to lack of reliable preservative measures rather than risk losses by bruchids during storage (Baribitsa *et al.*, 2012). Grain damage generally defined as insect emergence holes in beans, results in significant price discounts, reaching up to a 2.3% decrease in price for every hole per 100 beans (Mishili *et al.*, 2011).

To combat these storage pests, many extension offices promote pest control strategies such as use of metal drum, insecticide use and/or solar disinfection, though certain botanicals such as cypress, marigold, tagetes, and neem tree show moderate potential as storage treatments (Paul *et al.*, 2009; Quellhorst *et al.*, 2018). However, the moderate effectiveness of botanicals as storage protectants, the possible health concerns from insecticide use, and the labor intensity of solar disinfection practices provide shortcomings in their efficacy for common bean storage (Paul *et al.*, 2009). A new technology, Purdue Improved Cowpea Storage (PICS) triple-layer hermetic storage bags introduced by Purdue University with its partners, may provide an improved alternative for insecticide-free, long-term storage of common beans with minimal grain damage (Ognakossan *et al.*, 2010). In order to examine these issues raised, the objective of the study was to determine the potential impact of Purdue improved cowpea storage (PICS) technology on the income of users in north central Nigeria. The specific objectives include to:

- (i) describe socio-economic characteristics of users and non-users of PICS technology,
- (ii) determine the impact of PICS technology and
- (iii) estimate the impact of PICS technology on users income

2 RESEARCH METHODOLOGY

2.1 STUDY AREA

The study was conducted in the north central zone of Nigeria. It lies between latitudes 7° N 12° N and longitude 2° 30' E 12° E. The States within the north central are Benue, Kogi, Kwara, Nassarawa, Niger and Plateau. Its climate is characterized by two distinct seasons; rainy and dry seasons. The rainy season lasts from April to November with annual average rainfall of between 500 mm and 1200 mm. The southern part of the zone has higher rainfall percentage than the northern parts. The daily minimum and maximum temperatures range

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between 27 °C and 37 °C (night and day). Climatic and soil conditions of this zone favour the cultivation of rainfed legumes like cowpea. This zone though, small producer of cowpea but high consumer apart from being the transit states between the northern and southern part of Nigeria.

2.2 DATA COLLECTION AND SAMPLING PROCEDURE

The study used primary data, which was collected using a structured questionnaire to interview users and non-users of PICS bag. Trained enumerators under the supervision of the researcher administered the questionnaires. A multi-stage sampling procedure was employed in the study as shown in Table 1. The six north central states were selected for this study because of the high consumption rate of cowpea, participation in PICS project and the link states between the northern and southern part of Nigeria. Three Local Government Areas (LGAs) each from each of the three senatorial districts of the six north central states were purposefully selected due to high concentration of cowpea farmers and marketers. The cowpea farmers and dealers were identified. Secondly, 108 villages were randomly selected from sampled LGAs because of their output performance in cowpea production. Thirdly, 10 % of the 2,220 cowpea PICs stakeholders comprising 1,240 farmers and 960 traders’ were randomly selected by balloting with assistance of the state Agricultural Development Projects (ADPs). Lastly, the same number of non-users of PICS technology comprising 1,240 farmers and 960 traders’ were also randomly selected from study area through balloting as shown in Table 1.

Table 1. Sampling procedure and Sample Size

States	LGA	Villages	Population		Users		Non-Users	
			Farmers	Traders	Farmers	Traders	Farmers	Traders
Benue	9	18	210	170	21	17	21	17
Kogi	9	18	120	170	12	17	12	17
Kwara	9	18	120	160	12	16	12	16
Nasarawa	9	18	230	140	23	14	23	14
Niger	9	18	300	180	30	18	30	18
Plateau	9	18	260	140	26	14	26	14
Total	54	108	1240	960	124	96	124	96

2.2 ANALYTICAL TECHNIQUES

The double difference estimator was employed to achieve the impact of PICS technology on the income of users in the study area. The double difference estimator according to Verner and Verner, (2005) adopted by Oladimeji *et al.* (2017) compares changes in outcome measures (changes from before to after the project) between project participants and non-participants rather than simply comparing outcomes levels at one point in time. Therefore, to evaluate programme impact, Verners in their double difference estimator model version gave the model as:

$$DD = (Y_{p_1} - Y_{p_0}) - (Y_{np_1} - Y_{np_0}) \dots \dots \dots (1)$$

Where: Y_{p_1} = Income of users after PICS technology, Y_{p_0} = Income of users before PICS, Y_{np_1} = Income of non-users after PICS, Y_{np_0} = Income of non- users before PICS technology

The Propensity Score Matching (PSM) was used in association with the Verners’ method estimator to

achieve the impact of PICS technology on the income of users in the study area. One probability model for adoption of improved technology is estimated to calculate the propensity scores of adoption for each observation. Two each adopter is matched to a non-adopter with similar propensity score values, in order to estimate the ATT for the treated. Thereafter, logit model was used to estimate the propensity score (Ravallion, 2001). The Average Treatment Effect on the Treated (ATT) is defined as:

$$ATT = E \left(\frac{Y_1 - Y_0}{P=1} \right) = E \left(\frac{Y_1}{P=1} \right) - E \left(\frac{Y_0}{P=1} \right) \dots \dots \dots (2)$$

Where: ATT = average impact of treatment on the treated, N_1 = number of matches (from regression model), Y_1 = Average income of users’ income and Y_0 = Average income of non- users’ income. A positive (negative) value of ATT suggests that users’ of PICS bags have higher (lower) outcome variable than non-users.

Logit regression model was used to determine the probability of a respondent adopting PICS technology.

The underlying response variable y^* in the case of binary choice is defined as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_{11} X_{10} + u \dots \dots (3)$$

Where: Y = Usage, 1= user of PICS technology, 0 = non-user of PICS technology; X_1 = amount of credit accessed (Naira); X_2 = age of users (years); X_3 = educational status (years of formal schooling); X_4 = years of adoption of PICS technology; X_5 = household size (persons); X_6 = marital status (married =1, single =0); X_7 = labour for post harvesting handling (man-day) and X_8 = income (Naira); X_9 = quantity of cowpea handled (kg); X_{10} = membership of association $\beta_1 - \beta_{10}$ = the coefficients for the respective parameters in the logit function and u = error term.

3 RESULTS AND DISCUSSIONS

3.1 SOCIO-ECONOMIC CHARACTERISTICS OF RESPONDENTS

The distribution of socio-economic characteristics of PICS users and non-users is depicts in Table 2. Result indicated that both male and female were actively involved in usage of PICS bags. Respondents’ distribution by their educational level revealed that more than half (51%) of the users attended primary school. In the case of the non-users, majority (98%) do not have formal education. The average proportion of illiterates in the users’ group implies that the majority of them are in a better position to be aware of, understand and adopt improved cowpea technologies.

The result in Table 2 showed that the mean age of users and non-users farmers were 35 years and 38 years respectively and ranged from a minimum of 18 years and a maximum of 65 years with a standard deviation of 5.65 and 7.97 years respectively. The implication is that young people were more involved in farming and trading of cowpea in the study area. This implies that they were strong enough for tedious farm operations like farming, processing and storage. Hence, there is great potential of PICS technology having higher economic advantage in the study area. The distribution

of users and non- users of PICS technology by household size showed that one of the most important factors conditioning the level of production and adoption of PICS technology by small-scale farmers/traders is the composition and size of the household. Hence, the relatively moderate household size of the farmers/traders is an obvious advantage, since it may likely enable the farmers/traders to have more resources in their possession to do other pressing things compared to large household size with many responsibilities.

Table 2. Distribution of users and non-users of PICS technology by socio-economic status

Variables	Parameters	Users				Non-users			
		Farmer	%	Trader	%	Farmer	%	Trader	%
Gender	Male	65.00	52.40	51.00	53.60	66.00	53.20	53.00	55.20
	Female	59.00	47.60	45.00	46.40	58.00	46.80	43.00	44.80
Education (years)	Nil	5.00	4.00	3.00	3.10	41.00	33.10	31.00	32.20
	Informal	20.00	16.10	16.00	16.70	55.00	44.40	43.00	44.80
	Primary	63.00	50.80	49.00	51.00	18.00	14.50	14.00	14.60
	Secondary	24.00	19.40	18.00	18.80	7.00	5.60	6.00	6.30
Total	Tertiary	12.00	9.70	10.00	10.40	3.00	2.40	2.00	2.10
	Mean	124.00	100.00	96.00	100.00	124.00	100.00	96.00	100.00
Age (years)	Mean	35.02	-	36.06	-	38.35	-	39.83	-
	Minimum	26.00	-	26.00	-	26.00	-	28.00	-
	Maximum	53.00	-	51.00	-	58.00	-	58.00	-
	Std. Dev.	5.65	-	5.87	-	7.97	-	6.80	-
Household size	Minimum	3.00	-	3.00	-	3.00	-	3.00	-
	Maximum	11.00	-	10.00	-	14.00	-	9.00	-
	Mean	5.911	-	5.516	-	6.902	-	6.432	-
	Std. Dev.	2.649	-	2.148	-	2.792	-	2.504	-

3.1 IMPACT OF PICS TECHNOLOGY ON USERS INCOME

The difference in income between users and non-users of PICS technology is shown in Table 3. The result indicated a positive mean difference of about ₦1,205.12 per 50 kg bag in income was realized between users and non-users before and after using PICS technology. The difference in income was statistically significant at 1% level. The finding implies that there is an impact of the technology on the users of PICS bag in the study area. This conforms to the finding of Joktan and Sanni (2011) who observed that an increase in income of users (farmers/traders) of PICS technology by about 48% for cowpea stored within 4-6 months period in Nigeria.

Table 3. Double difference results of PICS technology on Users

Variable	Mean	Std. dev.	t-value	SE	p-value
DD	1,205.123	1.417	12.618	0.0955	0.000***

***= Significant at p<0.01%

The development of PICS bag had remarkable features of ensuring that cowpea farmers/dealers achieve good storage, increase prices leading to an appreciable increase in income. Therefore, to assess the impact of PICS technology on income of users a PSM was conducted using probability of participation (prediction) along with some other socio-economic variables.

The result in Table 4 specified that variables age, education status, employment status, income and quantity of cowpea were all statistically significant at 1% level of probability. The positive and significance of these variables implies that a unit increase in the coefficients of these variables lead to a correspondence increase in adoption of PICS technology among users. The result showed that the estimated coefficient (0.062) of age was positive and significant in influencing users'

income at 1% probability level. This implies that holding other factors constant, a unit increase in the age of the PICS users will increase the income from PICS bag by a magnitude of 0.062. On one hand, labour productivity is a function of variable age, it is believed that old people tends to adhere strictly to traditional methods of production while young people tends to be more willing to adopt new production methods in order to increase output and income. It is expected that the old that do adopt a technology do so at a slow pace because of their tendency to adapt less swiftly to a new phenomenon.

Education variable was positive and significantly influenced usage of PICS technology at 1% level of probability level. The estimated coefficient of 0.015 implies that the education in forms of seminars, workshops and trainings will increase by a magnitude of 0.015 the income for using PICS bags. Hence, education is a very important tool can be employed to enhance the adoption of PICS bags. A plausible explanation for this is that education enhances the acquisition and utilization of information on improved technology and management practices by the farmers as well as their innovativeness. Furthermore, education variable is known to facilitate farmers/traders ability to read and understand sophisticated information that may be contained in a technological package hence, and use of improved technology practices to better their lots. Furthermore income/dealers increase the likelihood of using PICS technology increases because with more income the farmers/traders can invest more to increase their output.

Quantity of cowpea stored variable was positive and significantly influenced usage of PICS technology at 1% level of probability level. The estimated coefficient of 0.011 implies that cowpea stored in PICS bag will increase by a magnitude of 0.011 units. Hence, PICS bags are a very important storage that reduces wastage.

Membership of cooperative society variable had the expected positive relationship and the effect of PICS bag on users' income and was statistically significant at 1% probability level. The estimated coefficient of 0.0811 implies that holding all other factors constant, the uses of PICS bags will increase the income by a magnitude of 0.0811 as their participation in their farmers' association increases by one unit. This is because membership in farmers' association affords the farmers the opportunity of sharing information on new innovations and technology.

Table 4. Estimates for Impact of PICS technology on Users' income

Variable	Co-efficient	S.E.	Wald	Sig.	Exp(B)
Access to Credit	0.162	0.263	0.378	0.539	1.176
Age	0.062***	0.027	5.089	0.024	1.063
Educational Status	0.015***	0.116	67.691	0.004	2.593
PIC experience	-0.014	0.016	0.741	0.389	0.986
Household Size	-0.118	0.092	1.628	0.202	0.889
Marital Status	-0.541	0.572	0.902	0.342	0.582
Employment status	-0.783	0.299	6.862	0.009	0.457
Labour	-0.084	0.058	2.09	0.148	0.920
Quantity of Cowpea	0.011***	0.036	0.233	0.629	1.017
Cooperative society	0.081***	0.225	15.316	0.005	2.414
R ²	0.541				

income

Table 5 estimated the propensity score matching (PSM) adjusted with constant coefficient value of 1.000 and is statistically significant at 1% level. The result leads us to the difference in PSM between users and non-users as presented in Table 6. The t-value was statistically significant at 1% level using two-tailed. This implies that there was an impact of the technology on the income of users of PICS bag in the study area. This indicates that (assuming there is no selection bias due to unobservable factors) level of impact of PICS technology on the income of users (farmers/traders) was significantly higher than the non-users.

Table 5. Propensity score matching result adjusted

Adjusted propensity score result	Step 0		Step 1
	Constant	PRE_1	Constant
B	1.000	4.966	2.470
Significance	0.000	0.000	0.000
Standard Error	0.095	0.512	0.276
Wald	0.000	94.072	80.034
Exp(B)	1.000	143.472	0.085

Table 6 Difference between propensity score matching for users and non users of PICS bags

Predictive matching score for Users & Non-Users	Score
Mean	0.25691
Std. Deviation	0.07678
Std. Error Mean	0.00518
t-value	49.630
Degree of freedom	219
Sig. (2-tailed)	0.000***

***P<0.01%

4 CONCLUSIONS AND RECOMMENDATIONS

From the findings of the study, the development of sustainable supply chain for PICS technology to make the technology available to farmers/traders is very crucial. It can be concluded that PICS bag technology has impact on the income of users. Since majority of farmers and traders are young and educated, trainings, workshops and sensitization should be encouraged. There is need to increase the level of awareness of the PICS technology to cover a greater percentage of farmers/traders. This can be effectively done using Agricultural Development Programmes (ADP), Non-Governmental Organizations (NGOs) and attending farmer’s stakeholders meeting for sensitization.

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