Analyses of Cowpea Grains Stored with Purdue Improved Cowpea Storage (PICS) Technology in Madagali Local Government of Adamawa State, Nigeria

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ABSTRACT: *Cowpea is a food security crop and a main source of income for farmers in Nigeria. However, postharvest storage remains a major challenge due to insect pest attack. Infestations impose serious challenge to cowpea storage and negatively affect trade and utilization of cowpea in Nigeria. Purdue Improved Cowpea Storage (PICS) technology provides effective control against these storage pests, thus, allowing farmers to tap into better grain prices during the lean season. The study analysed the gains in cowpea stored with PICS technology in Madagali Local Government Area of Adamawa State, Nigeria. The objectives of the study include; determining the effect of PICS technology use on cowpea loss and to estimate the returns to cowpea stored with PICS technology. Two hundred and forty (240) respondents were identified and interviewed using networking or snowballing non-random sampling technique. The analytical tools used for the study were the gravimetric (count and weight) method and marketing margin analysis. The result of the study showed that storing with PICS technology reduced weight loss in cowpea by 16.3%, valued at ₦3, 450 per bag per season. The use of PICS technology gave a higher marketing margin of ₦11, 297.88/bag with farm-to-retail price spread of 45.5% than ₦8, 285.83/bag and farm-to-retail price spread of 37.8% in woven bag. The study recommends that, farmers association be used as an avenue to promote and create awareness on the economic benefits of PICS technology.*

KEYWORDS: profitability, cowpea, storage, PICS technology, count and weight, Madagali

INTRODUCTION

Cowpea, *Vigna unguiculata*, is vital to the livelihoods of millions of people in the semi-arid region of West and Central Africa. It is the most important grain legume crop in sub-Sahara Africa. Cowpea is mostly grown by smallholders in the hot, draught-prone savannah and very arid Sahelian agro-ecological zones. Cowpea is a protein-rich grain that complements staple cereal and starchy tuber crops. A major staple crop in Eastern and Southern Africa, the common bean is estimated as the third-largest source of calories and the second-largest source of dietary protein (Hillocks *et al*, 2006).

With over 3.41 million tons produces annually (Food and Agricultural Organization Statistics [FAO], 2019), cowpea (*Vigna unguiculata*) play a key role in the agriculture and food supply of Nigeria. The seeds serve as a source proteins and vitamins for man, feed for animals, and also a source of income.

The young leaves and immature pods are eaten as vegetables. Over 90% of the population consume this grain as staple food (International Institute of Tropical Agriculture [IITA], 2009). The high share in consumption demand reflects the adoption in meeting food as well as protein-energy requirements both in rural and urban areas. Cowpeas are also a critical economic driver, promoting trade between producing and non-producing areas, with nearly 300,000 metric tons of cowpeas traded (Fulton et al., 2009). Adequate and sustainable supply of this crop will guarantee the nation's economic stability by reducing poverty level, improve health conditions and enhance productivity (Ajayi & Ajanaku, 2007; Kalu & Tomasz, 2010).

A widely noticed constraint in cowpea production, trade and utilization is insect pests' infestation during storage. The most prominent and destructive storage pests of cowpea are bruchids of the genus Callosobruchus (Coleoptera chrysomelidea), which infest cowpea grains both in the field and in storage causing extensive grain weight losses through their feeding (Boxall, 2002; Golob, 2002). Losses in dry weight of cowpea due to bruchid damage have been estimated at about 30-40% of stored cowpea in Nigeria (Tapondjou et al., 2002).With direct physical (weight) loss, manifesting in seed perforation causing substantial reductions in market value and germination ability of seeds (Santos et al., 1990). Indirect damage includes contamination of their feeding media with faeces, exoskeleton, insect body parts, dead bodies and their own existence in the product is often not commercially desirable.

While the risk and magnitude of losses increases the longer the grain is stored, farmers are limited in strategies to cope with storage loss (Kadjo et al., 2013). Most traditional grain storage techniques (such as local rhombus, bags, open field, roof and fire place) commonly used by rural farmers cannot guarantee protection against these storage pests (Gitonga et al., 2013), and have been reported to cause significant grain waste and losses of about 25 per cent of farmers' harvest (Boys, 2005; Moussa, 2006). While the chemicals (insecticides) control protocols are frequently unavailable or too expensive for individual and even farmer groups, they are most often subjected to misuse thereby raising economic, technical and safety concerns (Baributsa et al., 2012). As a result, long term storage remains a huge problem for the rural farmers.

Farmers, being faced with high rates of potential losses, selling at harvest may be an optimal strategy to avoid losses due to pest damage. Thus, farmers are consistently forced to sell immediately after harvest when prices are lowest in order to avoid storage losses, and this is a disadvantage to farmers (Moussa et al., 2012). According to Kadjo et al., (2013), early sales reduce farmers' profit and the potential for producers to take advantage of price increase after harvest. Afolami and Falusi (1999) opined that forced early sales can interact with or induce market failure and reduce farmers' market participation, with adverse consequences for the poor. This is because, farmers' market participation is directly related to their ability to generate marketable surplus (Sharma & Wardhan, 2017). According to Onyango and Silim (2000), without proper storage facilities, high value market will remain largely inaccessible to the smallholder farmers, as this will hinder engaging in temporal arbitrage in the presence of substantial seasonal price fluctuations that increase income (Gilbert et al., 2017; Tesfaye & Tirivayi, 2018).

It has been estimated that every insect emergence holes present in 100 seeds reduces the price of the grain by 2.3% (Jones et al., 2014; Mishili et al., 2011). Apart from the loss of monetary value (lower unit prices paid), storage loss also tightens food market by removing part of the supply from the market, contributing to farm-gate prices spikes (Rosegrant et al., 2015). FAO (2011) stated that for every 1% rise in food prices, expenditure on food drops by 0.75% in developing countries. Safe storage of cowpea at the farm level is therefore critical to improve productivity, trade and utilization of cowpea, as this will directly impact poverty alleviation, food security, while improving livelihood and income of smallholder farmers.

The Purdue Improved Cowpea Storage (PICS) triple-layer hermetic storage bags have been promoted as improved alternative for insecticide-free, long-term cowpea storage in Nigeria. Evidence has shown that when tied shut, PICS technology ensure effectively airtight low-oxygen (less than 5% by volume) environment are generated through the respiratory action of the seeds and enclosed pests (Murdock et al., 2012). The modified atmosphere (enriched carbon dioxide (CO_2) environment suppresses the survival of insects and reduce damage caused by their feeding (Baoua et al., 2014; Tubbs et al., 2016). This will provide smallholder farmers with the flexibility to store grain for several months (Swathi & Rajanikanth, 2017), thus allowing them to tap into better grain prices during the lean season. The objectives of the study includes; to determine the effect of PICS technology use on cowpea loss and to estimate the returns to cowpea stored with PICS technology as against GP Tanks in Madagali Local Government Area of Adamawa State. Understanding this will provides farmers with information that will facilitate decision making based on sound economic analysis.

METHODOLOGY

The Study Area

Madagali local government was created by General Ibrahim Badamasi Babangida administration in August 1991 with headquarters at Gulak. Madagali local government is named after the town Madagali. Settlement in Madagali local government area sprang up after the Fulani's invaded and sacked the inhabitance of Birnin Ngazargamo in 1812. Madagali local government area is located at the end of the northern part of Adamawa state. It occupies a land area of 903 square kilometres and has a population of 231, 061 by (National Population Commission, 1992). It is bordered by Borno state to the north, the Cameroun republic to the east and Michika local government area to the south.

The local government area is positioned between longitude 13^0 15' to 13^0 50' East and latitude 10^0 30' to 11^0 North. It has an elevation of 2,000 feet (666.67 metres) above sea level.
Madagali Local government is comprised predominantly of Marghi, Higgi, Sukur, Wulla, Fulani, Hausa, Igbo, Kanuri, others are Yoruba, In terms of religion Madagali local government comprises of two major religions which are Islam and Christianity. About 90% of the people of Madagali are farmers; agriculture is the major occupation in the area. The major crops cultivated in the local government area are cowpea, maize, rice and groundnut.

Sampling Procedure / Techniques

The study was conducted in Madagali Local Government Area of Adamawa State. Stratified random sampling technique was used for the purpose of the study. This is because the samples were divided into sub-groups or strata in four formats. The first facilities were three set of PICS bags which were filled with clean dry cowpea grains and sealed. The second facilities were also three set of G.P Tank filled with clean dry cowpea grains and sealed. The third facilities were three set of polyethylene bags filled with clean dry cowpea grains treated with phostoxin tablet and sealed while the fourth one were also three set of polyethylene bags filled with clean dry cowpea and sealed without any treatment (control), each treatment weighing 90k. The three different set of treatment (PICS GP Tanks and control) were kept suspended at about 0.5m above ground level using wooden pallet, attached with rat guard to prevent rat from attacking the sample. The PICS bags and G.P Tank and phostoxin tablet were used in storing the cowpea grains so as to test the efficacy of the PICS bags, G.P Tank and phostoxin against *Callosobruchus maculatus* on the stored cowpea grains.

Analytical Techniques

The gravimetric (count and weight) method

The weight loss (WL) at different storage bags was determined using the count and weight method as proposed by Boxall (1986). This is given as:

$$\%\ weight\ loss\ = \frac{(UNd - DNu)}{U(Nd + Nu)} * 100 \qquad (24)$$

Where,
U = weight of undamaged grain,
Nu = number of undamaged grains,
D = weight of damaged grains,
Nd = number of damaged grains.

Marketing Margin Analysis

Marketing margin analysis was used to determine the returns to cowpea storage between users and non-users of PICS hermetic technology. This was determined using the approach adopted by Murthy et al (2007), which estimates marketing margin as the difference between farm-gate price and the selling price. The net marketing margin is calculated by obtaining the difference between what is received and cost incurred. This is mathematically presented as:

$$GMM = SP - FP$$

$$NMM = GMM - \text{TMC}$$

Where,
NMM = Net Marketing Margin (₦);
GMM = Gross Marketing Margin (₦);
SP = Sale Price (₦);
FP = Farmgate Price (₦);
TMC = Total Marketing cost (₦);

Total marketing cost consists of both variable and fixed cost incurred during the marketing operation. Variable costs are direct costs incurred during marketing activities such as handling costs, packaging materials, and transportation as well as post-harvest storage loss. The fixed cost consists of the depreciation on all fixed assets which can last for a year or more. This analysis therefore considers the ability of PICS bags to be used for three seasons and PP bag for two seasons. The cost of the storage bags was straight-line depreciated over its useful life. The formula is given by:

$$d = \left\{\frac{c - s}{n}\right\}$$

Where,
d = depreciation (₦)
c =purchase value of an asset or cost (₦)

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s = salvage value of asset after its expected years of usage (₦)
n = life span of the asset (years)
The farmers' share measured as a percentage of selling price was then derived mathematically as:

$$\text{Farmers' share} = \frac{SP-FP}{SP} x100$$

Where,
SP = Sales price at the retail market
FP = Farm-gate price at the producer end

RESULTS AND DISCUSSION

Table 1: Percentage Loss in Weight of cowpea stored with PICS and GP Tank

Category	Average Weight loss (%)				Loss (kg/bag)*
	Initial loss	2 months	4 months	6 months	
GP Tanks	0.24	2.91	8.55	18.37	16.7
PICS bag	0.24	0.78	1.84	2.04	1.84
Abated loss (bag/season)				**16.33**	**14.8**
Abated gain (₦/bag/season) - ₦250 per kg					**3,450**

Source: Field survey 2020 $*WLx90/100$

Table 1 shows the percentage loss in weight of cowpea stored with PICS and GP Tank. The result showed that, at the onset of the trial, cowpea in both PICS and GP Tanks were slightly damaged by bruchids, and had an average weight loss of 0.24%. At two to four months of storage, grain damage was much lower in the PICS bags than in GP Tanks. After six month of storage, the weight loss increases significantly to 18.37% for grain stored in GP Tanks representing quantity loss of 16.7 kg per 90 kg grain. While weight loss in PICS bag was 2.04%, which amount to quantity loss of 1.83 kg per 90 kg grain. The abated loss through the use of PICS bags was 16.33%, which equals 14 .8kg grain saved and valued at ₦3, 450, assuming farmers store for six months only.

Table 2: Estimated Marketing Margin per bag of Cowpea

Variables	**Users Value (₦/bag)**	**Non-users Value (₦/bag)**
Selling Price: SP	24,812.05	21,908.33
Farm-gate price: FP	13,514.17	13,622.5
Gross Marketing Margins: GMM = SP-FP	**11,297.88**	**8,285.83**
Marketing cost items:		
Labour	1,311.02	1,169.89
Insecticide	0	300.02
Transportation	661.81	642.35
Storage (weight) loss	457.5	3,900.0
Market charges	135.0	110.0
Storage bag	193.3	115.0
Store rent	1,377.82	1,036.37
Total marketing cost	**4,136.45**	**7,273.63**
Net Marketing Margins: NMM = GMM – TMC	**7,161.43**	**1,012.2**
Margin as % of selling price	**45.5**	**37.8**

Source: Field survey 2020

Table 2 shows the marketing margins, cost, and farmers' share in cowpea marketed in the study area. From the result, the average farm-gate price per bag (or per 100 kilograms) of cowpea was ₦13, 514.17 and ₦13, 622.05, while the retail price was ₦24, 812.05 and ₦ 21, 908.33 for the users and non-users of PICS technology, respectively.

The result of the gross marketing margin shows that without considering the associated costs incurred in marketing, the users had gross margin of ₦11, 297.88 per bag (or per 100 kilograms) while the non-users had gross margin of ₦8, 285.83. This shows that the users received a higher return from cowpea sale than the non-users. This could be due to better price arbitration resulting from quality grain and longer storage with PICS bag.

Considering the marketing cost, it was evident that the cost of store and labour constituted the largest cost component for the users, while post-harvest storage loss and labour constituted the highest cost for the non-users. The total marketing cost incurred by the users and the non-users was ₦4, 136.45, and ₦7, 273.63, respectively. Thus, the net marketing margin earned by the users per bag (or per 100 kilograms) of cowpea marketed was ₦7, 161.43, which was higher than the non-users value of ₦1, 012.2. This implied that more was spent by non-users of PICS technology on marketing services such as cost of transportation, storage, rent, and market levy compared to the amount received for value addition in cowpea retails marketing.

In addition, the famers' share as a percentage of selling price showed that, the users received higher share of 45.5%, compare to 37.8% share for the non-users of PICS technology. This implied that PICS users earned a higher share from what the consumer than the non-users storing with GP Tanks bag. This therefore indicated that a 100% retail price paid by the final consumer will result in farm-to-retail price spread of about 46% for the users and 38% for the non-users. In order words, an average cowpea marketed in the study area earned a farm-to-retail spread of 0.46 Naira to the users and 0.38 Naira to the non-users, for every 1 Naira retail price paid by the final consumer in the marketing process. While the remaining 54.5% and 62.2% of the consumers' expenditure on cowpea will go to other marketers in the marketing system.

CONCLUSION

The research findings revealed that PICS technology helped farmers abate grain weight loss of 15.3% (13.8kg) valued at ₦3, 450 per bag per season. This showed that PICS was more effective in reducing storage loss caused by insect infestation, and better quality grain than with GP Tanks. Also, the use of PICS bags presents higher return and price share to users per season. This is evident that the use of PICS technology has a better economic impact than storing with GP Tanks.

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