Profitable chemical-free cowpea storage technology for smallholder farmers in Africa: opportunities and challenges

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Abstract

Cowpea is the most economically and nutritionally important indigenous African grain legume, grown by millions of resource-poor farmers. It is a key cash crop in areas too dry to grow cotton or other export crops. Most of the over 3 million t of cowpea grain produced annually in West and Central Africa is grown on small farms. Storage is often identified as the key challenge for small scale cowpea growers. Many farmers sell cowpea grain at low harvest time prices rather than risk losses by bruchids during storage. Some traditional methods are effective for small quantities (e.g., 10 kg), but are difficult to scale up. Some effective storage chemicals are available, but they are regularly misused by farmers and merchants. The Purdue Improved Cowpea Storage (PICS) Project is addressing these problems through promotion of hermetic storage in triple layer sacks which have an outer layer of woven polypropylene and two liners of 80 µ high-density polyethylene. Village demonstrations with more than 45, 000 PICS sacks have shown the technology to be effective. Good quality affordable sacks have been produced by manufacturers in Nigeria, Burkina Faso and Mali. Over the past three years more than one million sacks have been produced and sold. Despite the success with the outreach activities and the farmer adoption, the challenge remains to develop sustainable sack distribution networks. Issues identified include reluctance of wholesalers to order sacks due to risk associated with a new product, inability of wholesalers to develop effective distribution networks due to difficulties with enforcing contracts, and limited access to capital. The PICS project is exploring new ways to address some of these issues, including using non-traditional distribution systems for PICS sacks such as agro-dealers networks, and adapting distribution systems that have worked for cell phones and other products.

Keywords: Cowpea, Bruchids, Hermetic storage, Supply chain, West and Central Africa

1. Introduction

Cowpea is the most important economically and nutritionally indigenous African legume crops, especially in West and Central Africa (WCA). Cowpea is rich in protein and constitutes a staple food for people in rural and urban areas. It is used for family consumption as well as sold in the local market for much needed cash. In the 1990s in WCA, cowpea production, mostly by small-scale farmers, was estimated at 2.6 million tons on about 7.8 million hectares, 69% of the world production (Langyintuo et al., 2003). Both area planted to cowpea and production has expanded in the last decade, with production now averaging over 3 million t annually. Cowpea is also an important cash crop in the region with potential for entering commerce. It is estimated that around 80% of the cowpea trade in the world is in WCA. In the late 1990s, official cowpea trade accounted for over 300,000 t of cowpea per year within the Nigerian Cowpea Grainshed (Langyintuo et al., 2003; Langyintuo et al., 2005; Langyintuo and Lowenberg-DeBoer, 2006). However, marketing and trade is severely hampered by storage insects, especially the cowpea weevil (Murdock et al., 1997).

Moussa (2006) and Boys (2005) indicate that a conservative estimate of cowpea storage loss is 25%. Cowpea bruchids are seed beetles that develop and reproduce rapidly in stores of cowpeas. A female cowpea bruchid, just emerged from her seed and newly mated, can produce 60-120 eggs (Fox, 1993), hatch into larvae, most of which survive to adulthood and begin reproducing. In warm climates, the time required for a full generation is short, as little as three and one-half to four weeks. As a result, a freshly threshed store of cowpeas with only a small initial bruchid infestation can be rendered inedible and worthless in the market within two or three months.

Farmers use a variety of commercial and traditional methods to control bruchids, many of which have restricted value because of cost, labor and potential toxicity. For instance, insecticides can be used to control cowpea weevils, but poor farmers often do not have access to these insecticides and when they do, they often misuse them resulting in health and environmental problems. Ash is also used for cowpea storage, but only for small quantities due to labor requirement and because many people consider ash as "dirty" and refuse to eat food stored in ash. Other cowpea storage methods include metal drums, widely available and used in northern Senegal and south Benin. It was estimated that about 60% of cowpea production in the main cowpea area in Senegalese was stored in metal drums (Boys et al., 2007). In recent years, there has been a decline in metal drum use due primarily to their cost and the inflexibility of drum storage to production quantities. In addition, many farmers were using insecticides to store cowpea in metal drums because many were rusting (hence, no longer air tight). Moussa (2006) reported that farmers used insecticides when storing cowpea in single or double layer plastic bags. Adoption studies conducted at the village level in WCA revealed that growers were very interested in hermetic storage for cowpea, but lack appropriate containers and information about proper storage (Moussa, 2006; Boys, 2005).

2. Purdue improved cowpea storage (PICS) technology

To further improve cowpea storage and address some of the issues mentioned above, Purdue University with its partners initiated the Purdue Improved Cowpea Storage

(PICS - http://www.ag.purdue.edu/ipia/pics)

project which was funded by the Bill and Melinda Gates Foundation. The goal of the project is to have 50% of farm-stored cowpea in hermetic storage without insecticides in West and Central Africa by 2012. The objectives of the project are to (i) determine the best design for a one-piece commercially available triple-layer plastic cowpea storage bag; (ii) disseminate information on non-chemical cowpea storage methods to extension services, non-governmental organizations (NGOs) and farmers; (iii) demonstrate the most effective cowpea storage methods in each village in the major cowpea production areas of WCA; and (iv) develop and foster local businesses that provide triple-layer plastic storage bags.

The benefits from improved storage include increased cowpea trade in the region, hence, enhanced incomes of small-holder farmers and the food supply to consumers in the region. This project is implemented by Purdue University in collaboration with many partners including the International Center for Tropical Agriculture (IITA), World Vision, the National Institute for Agricultural and Environmental Research (INERA) of Burkina Faso, the National Agricultural Research Institute of Niger (INRA) and other national agricultural research systems, NGOs, farmer associations and private sector partners.

The triple layer technology was originally developed to enable Cameroonian farmers with few resources to store their cowpea grain safe from losses to seed beetles; as experience with the technology grew, it began to spread across into West Africa. The foundation for the current PICS technology was triple bagging of cowpeas, developed under the USAID-supported Bean/Cowpea CRSP in the late 1980's (Murdock et al., 2003). The triple layer bagging technology subsequently began to be adopted in various countries in WCA.

The PICS technology owes its effectiveness to the airtight storage enabled by the PICS bags. Threshed cowpea grain is put into 50-or 100-kg capacity high density polyethylene (HDPE) bags with walls 80 µ thick, taking care to fill the bag completely, without air pockets, except for a neck of 20-30-cm length. This first bag is tied securely shut at the neck and then surrounded by a second bag of the same material and thickness. The middle layer bag, completely surrounding the first, is tied shut at the mouth in the same way as the first. These two sealed bags are then placed inside a third plastic bag, which is woven nylon or polypropylene, for strength. This container thus formed can be handled without bursting the inner bags, and is readily accepted by grain handlers since it is the same type of plastic bag they are accustomed to storing cowpea grain in. A step-by-step how-to-use PICS technology can be found at http://www.ag.purdue.edu/ipia/pics/Documents/PICS_English_Nigeria.pdf.

PICS bags work – as do other hermetic storage contains such as sealed steel drums (Seck et al., 1996) – because insects respire aerobically and thus utilize the oxygen in the airtight container while also raising CO_2 levels. Once the oxygen level in the container falls sufficiently low, insects cease feeding and

become inactive (Margam, 2009). Inactivity itself causes growth and development to cease and in turn reproduction stops. This results in the arrest of population growth. During the oxygen deficit-caused inactivity insects begin dying. the early-instar larvae and pupae appear to be particularly vulnerable.

3. PICS technology capacity building and outreach approach

The PICS project started with pilot programs during the first year in both Burkina Faso and Niger to evaluate the alternative extension methods. The outreach program focused on village activities by trained field technicians. Training was implemented at various levels. First, a workshop for trainers of field technicians was held in each country. The objective of the workshop was to educate trainers about how to facilitate and conduct train-the-trainer sessions for field technicians. Thereafter, there were train-the-trainer sessions for field technicians who would implement village activities.

The core extension program focuses on PICS technology awareness building through village level activities involving multiple visits by trained field technicians. Village activities include sensitization, demonstration, follow-up and open-the-bag ceremonies. Experience in Cameroon in the 1990s by the CRSP and its NGO partners suggested that village level demonstrations were the single most effective method for facilitating adoption and was extremely cost effective (Moussa, 2006). Village activities included a three-step process:

- The technician begins with a sensitization visit to the village to explain the technology, obtain a commitment for the village to participate, and set up a date/time for the village demonstration.
- A subsequent activity is the first demonstration, carried out soon after cowpea harvest. Most farmers in WCA are illiterate, so demonstration is the most effective method of technology transfer or extension education. In each village, the project provided five to 10 triple-layer sacks for conducting demonstrations. Farmers volunteer their cowpea and the sacks are filled during the demonstrations. The filled sacks are then kept in a community storage facility until the open-the-bag events that occur four to six months later. During village demonstrations, the technicians show step-by-step how to fill and tie the bag and then supervise the filling of the remaining bag by farmers. PICS demonstrations include training on how to distinguish an acceptable bag for storing cowpea and how to test bags for air tightness. In the months following the demonstration, the technician would visit the village and hold informal meetings and inquire about the bags of cowpeas.
- The third contact, between four and six months after harvest, is the open-the-bag ceremony. This event is key component of the successful technology transfer because most farmers are illiterate and the concept (depletion of oxygen) that lies behind hermetic storage is abstract to most of them.

The project has made a strong effort to use the media, radio mostly, for communicating the PICS message to rural communities. Most rural people in the region do not have access to television. Radio is the most widely used medium of mass communication in WCA. PICS radio messages are broadcast on radio during village activities (sensitization, demonstration, follow-up and open-the-bag events). In addition, a commercial message is broadcast during the harvest season and storage period, focusing on the availability of PICS sacks in various locations of the country. Comparisons of adoption in villages with and without PICS radio messages indicate that radio has a significant effect in reinforcing the use of the PICS sacks (Moussa et al., 2009).

Posters have also been printed and distributed to PICS sacks vendors, extensions agents and NGOs implementing the PICS activities, and to community radio. Recognizing the expanded use of cellular phones in rural Africa, the project has developed a video sketch on the use of the PICS technology in the Hausa language and in French. The cellular phone videos are being transferred via bluetooth and represent a way to overcome issues related to explaining a concept that is simple but difficult for some farmers to follow without seeing a demonstration.

4. Supply chain development for PICS sacks

To sustain the availability of triple-layer sacks to end-users, the project is developing a supply chain throughout the cowpea growing areas of WCA. To develop this, the PICS project has been focusing on developing processes and systems through the whole supply chain that ensure product quality and assure availability by fostering working relations among the supply chain members, namely: manufacturers,

distributors/wholesalers, semi-wholesalers, sack vendors/merchants and retailers or rooming vendors (Figure 1).

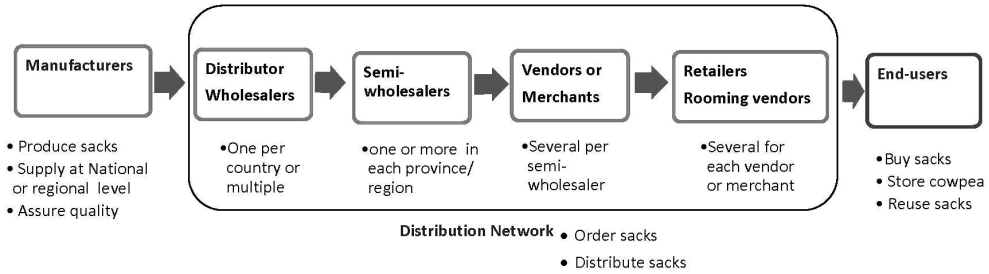

Figure 1 PICS sack Supply Chain- distribution of PICS sacks from the manufacturer to the end-users

Active engagement with the supply chain is achieved through training, relationship building and monitoring. In some cases, this included financial help in making the first order of PICS sacks. The process for the development of the supply chain involved several steps:

- First, the PICS project assessed the availability of plastic manufacturers in each country. If a local manufacturer is not found or local manufacturers cannot meet quality or cost criteria, then the project initiates discussions with manufacturers in neighboring countries or elsewhere in the WCA region. It is best to work with local manufacturers if they are price competitive and can also guarantee bag quality (can meet sacks specifications- e.g., high density polyethylene inner liners 80 µ thick). Given that PICS is a new product, minimizing the cost of production and transportation help keep the price down compared to alternative technologies, which provides an incentive for farmers to use it. However, PICS has relied on outside-the-country manufacturers in some cases.
- Second, the project identifies a distributor who has the means to finance the PICS sack order and also has a network to distribute them. In the past few years, the PICS has experimented with various alternatives for developing the distribution network for selling PICS sacks. During the pilot program, the project used NGOs and extension services as venues for selling PICS sacks to farmers. But this approach did not function well because there were few incentives for selling more bags. Most NGOs and extension services were more concerned about inventory control (e.g., preventing pilfering) than in sales. Recently the project started partnering with traditional sack merchants and emerging networks of agro-dealers, many of whom do not have well-developed distribution networks.
- Third, PICS supported the development of the supply chain by creating demand through media and village awareness activities (sensitization, demonstration, etc.). PICS activities have been carried out in over 23,000 villages in Nigeria, Niger, Burkina Faso, Benin and Togo in the last three years. In addition, the project assists distributors to expand their network, through business consultants, by recruiting and adding new members into their networks. Market and point of sale demonstrations are also conducted to increase awareness of the PICS technology. The project originally targeted only farmers for information and training, but realized that building a sustainable supply chain for the PICS sacks required reaching out to all potential users, including grain merchants, public and private organizations.

While PICS agreements with manufacturers and distributors vary from country to country, the basic strategy is (i) to demonstrate the potential for demand for PICS sacks to both the manufacturer and the distributor; (ii) facilitate expansion of distribution network by working with distributors to identify major cowpea-growing areas not yet covered by their network and to find potential retailers in those areas; and (iii) transfer the risk to both the manufacturer and the distributors by requiring that all orders in the year after full-scale implementation of PICS (usually the second year) be made without financial assistance of the project.

5. Opportunities and challenges in implementing project activities:

The PICS technology has been quickly adopted by small-scale farmers and other organizations because of its effectiveness and ease of use. In addition, the cost of the sack has been relatively low when compared to other alternatives (metal drums, single or double layer plastic bags in conjunction with pesticides or traditional methods that are labor intensive and often less effective). The price of a PICS sack ranges from US $2 to US $4 depending on the country and location. In general, farmers have not complained about the price of the bags, but about availability. They would like bags to be on sale in their local market or local shops. The most vigorous criticism about bag prices come from grain merchants who would need to buy many bags (i.e., hundreds or thousands) if they were to adopt hermetic storage.

Another advantage of the PICS technology is that it can be produced in most countries or in the WCA region. Geographic proximity remains a critical factor that influences the price of the technology at the farm level, given that cost of transport is very high in many countries due to poor infrastructure connecting major cities with rural communities where the sacks are used.

In addition, the PICS technology provides business opportunities to local manufacturers, business entrepreneurs and rural communities for producing and selling PICS sacks, and storing cowpea grain at harvest and selling it later when the prices are high. Farmers and traders have an economic motive for storage because cowpea prices often double or triple from harvest time lows to seasonal highs in the months before the next harvest. The investment in the PICS sack is small compared to the return for storing cowpea in PICS sacks for some months. For example, at harvest in Kano Nigeria, if a farmer sells cowpea he/she earns 5000 Naira (100 kg at 50 Naira per kg). If a farmer decides to sell it later six months later, then he/she may earn 9700 Naira (100 kg at 100 Naira per kg minus 300 Naira for a PICS sack).

Because the PICS sack is a new product to many farmers and sack vendors, there is a reluctance to purchase them in the first year. However, once farmers have witnessed the effectiveness of the technology during the open-the-bags events, many more are willing to purchase and use the sacks. Since the beginning of the project in June 2007, almost 1.25 million PICS sacks have been manufactured (Table 1). Of those, about 148,000 sacks have been used in demonstrations. Over one million sacks have been sold overall. The largest single buyer was Nigerian Office of Food Products (OPVN), with 800,000 bags. Small holder farmers and traders have purchased about 240,000 sacks. While challenges remain, the PICS sack supply chain is rapidly transitioning from a project activity to a private business. Some distributors and wholesalers are adapting models that have worked for other products such as the route-to-markets used by Celtel Company to improve inventory management and cash recovery. During the first and subsequent years of the project, it has been a challenge to estimate the demand for sacks. It is hard to predict the markets given that (i) the PICS sacks is a new product; (ii) there is no reliable data or service that could provide this type of information; and (iii) the potential for reuse of the PICS sacks.

Table 1 Estimate of PICS bag inventory by country and year, number of sacks ordered and remaining for each cowpea harvest season since the beginning of the project in 2007.

		Harvest season						
		2007/2008		**2008/2009**		**2009/2010**		
		PICS	**Others**	**PICS**	**Others**	**PICS**	**Others**	**Totals**
Niger	Ordered	20000	0	100000	400000	0	410000	930000
	Remaining*	15566	0	28,347	0	0	5000	1780
Burkina Faso	Ordered	20000	0	95000	0	0	23000	138000
	Remaining	18396	0	48000	0	0	14000	14000
Nigeria	Ordered			5000	4800	100000	20000	129800
	Remaining			2900	1900	2900	20000	22900
Mali	Ordered					25000	0	25000
	Remaining					11483	0	11483
Benin	Ordered					12500	0	12500
	Remaining					4826	0	4826
Togo	Ordered					12500	0	12500
	Remaining					6000	0	6000
NB:	* remaining inventories are sold the following cowpea harvest season							
	= Rough estimates					= Pre-project in these countries		

Given that most business is based on trust and relationship, growing the distribution network has been difficult. This is because each wholesaler will only work with a limited number of retailers whom they know. Each of the retailers can only maintain relationships with a certain number in the next layer (e.g., vendors who go to traditional markets). This leads to several issues associated with the development and expansion of the PICS sack distribution network, among them: (a) wholesalers are reluctant to provide inventory credit and insist on cash-and-carry to new vendors identified by the project; and (b) reliable vendors are not available in some areas, etc. The lack of access to credit has also made manufacturers require a downpayment at the time of the order so as to manage the risk, even from distributors who are already part of their customer base buying other types of sacks.

Pricing and affordability of the PICS bags is important: the price is too high, farmers and other users will not buy them. In the first year of PICS price was set to cover average manufacturing, transport, handling and retail costs. The manufacturer-to-retail margin was set at 10% to 15% based on interviews with traditional sack merchants. A uniform recommended price was established and enforced by publicizing the recommended price on radio and by regular contact with vendors to monitor prices. The project quickly learned that not allowing vendors to earn adequate margin would compromise the effort to develop a distribution system. Setting the price was leading distributors to keep most of the margin, hence, creating less incentive for vendors in the lower layer of the distribution system to sell the sacks.

Given the lack of quality-control enforcement mechanisms in most WCA countries, it is almost inevitable that when a demand develops for PICS bags, lower quality bags will be marketed. There have already been reports of fake sacks marketed in Niger and Nigeria. To assure quality, Purdue University has trademarked the PICS logo. This will provide a legal tool to pursue those who make low quality bags and try to use the PICS logo.

Some farmers have successfully used PICS sacks to store a variety of crop products such as bambara groundnuts, sorrel grains, maize, sorghum, and millet. Diversifying the use of PICS sacks to other crops may in fact increase the demand for PICS sacks and will provide opportunities to both the PICS sacks vendors and end-users who will be able to preserve their other crops.

6. Conclusions

In countries where PICS hermetic storage technology has been demonstrated, farmers have quickly adopted the technology. The technology is simple to use, affordable, pesticide free and scalable. PICS bags can accommodate whatever quantity the grower has. The PICS bags provide storage opportunity to farmers and consumers interested in organic and bio products. While the project has made significant progress in disseminating the PICS technology, it may take longer than originally planned to develop the sack distribution networks. Like any other new product launched on the market, it takes time to make consumers aware of the product and to get it fully embraced by members of the supply chain. Based on the first two years of the project we have learned the following lessons: i) diversifying/regionalizing distributors will help address issues related to potential size (development and management) of the distribution network; ii) during the first year, requiring the wholesalers/distributors to put a 20% down payment at the time of order helps identify those who are committed and serious; iii) it is better that PICS sack distributors and retailers run out of sacks in the first year, rather than holding sack inventories. Unsold bags create cashflow issues with manufacturers and the PICS project; iv). during the second year, allow vendors to set sack prices and provide them with information on sack demands from the first year; and vi) conduct business with literate merchants – they are more likely to take written or verbal agreements seriously.

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