



Farmers in West and Central Africa obtain economic benefits from enhanced cowpea storage technologies

B. Moussa, J. Lowenberg-DeBoer, J. Fulton, and K. Boys

Researchers from the Bean/Cowpea Collaborative Research Support Program (B/C CRSP) developed several nonchemical cowpea grain preservation technologies in the 1980s, including hermetic storage in airtight containers (metal drums, multilayered plastic bags), improved ash storage, and a solar heater. Early efforts to assess the impact of these technologies were limited to specific studies in countries where they were initially developed and disseminated; however, researchers at Purdue University recently evaluated the regional benefits of these technologies. This impact brief summarizes the results of that study.

CRSP research contributes to improving cowpea storage technologies

Cowpea is the most economically important indigenous African legume crop. About 87 percent of the 8.7 million hectares planted with cowpea worldwide are planted in Africa. Recognizing the important role of cowpea to low-income farmers, the B/C CRSP supported research and extension linkages between West and Central African cowpea researchers and their U.S. counterparts between 1982 and 2007. Storage of cowpea is a challenge for farmers in West and Central Africa. Insect pests infest the cowpea grain both in the field and in storage and degrade its nutritional quality and economic value. Thus, producers often sell at low harvest prices to avoid storage losses. To help improve household food security and producer income, the following improved storage technologies were developed from this collaboration:

1. hermetic storage in recycled metal drums
2. a triple bagging technique
3. an improved ash storage technique
4. a solar heater

While the first technology was developed in Senegal, all the other technologies were developed in Cameroon and have since been disseminated throughout West and Central Africa.



A cowpea producer using enhanced storage technology in Africa

Pulse CRSP: Contributing to Economic Growth and Food and Nutrition Security in Latin America and Africa

Key Findings

- Approximately 30 percent of grain in Benin, Burkina Faso, Cameroon, Mali, Niger, Nigeria, and Senegal is stored using the CRSP-developed double and triple bagging or closed metal drum storage techniques.
- While the use of the improved ash storage method was concentrated in Burkina Faso, Mali, and Cameroon, the adoption of solar heaters was limited to a few villages in Cameroon and Burkina Faso.
- Country-level returns to investments in R&D were estimated to be highest for Burkina Faso (132 percent), followed by Benin (95 percent) and Mali (88 percent.) At the regional level, the internal rate of return (IRR) was estimated to be 28.6 percent and the net present value (NPV) for 1982–2020 was estimated at more than \$295 million USD.

Traditionally, cowpea grain could be stored on platforms and in granaries (plant materials, clay, and mud), bins, airtight underground pits, baskets, jars, and woven bags. Hermetic storage of grain is an ancient practice. CRSP researchers identified locally available containers that could be used for hermetic storage. In Senegal, metal drums were identified as appropriate grain storage containers; however, since these containers have high-priority uses in other countries in the region, their use for storing cowpea grain was limited. As such, researchers in Cameroon identified an alternative triple bagging hermetic storage technique in which the grain is stored in two heavy-duty plastic bags that are then placed in an outer woven jute or polypropylene bag. Some farmers have adapted a modified, double bagging version of this technology that uses only one inner plastic bag plus an outer woven bag.

A third CRSP innovation was the enhancement of the ash storage technique. CRSP scientists at Purdue University determined that placing equal volumes of sieved ash and cowpea grain in a container covered by an additional three-centimeter layer of ash was the optimal implementation of this technique. Use of this method is constrained, however, by the limited availability of ash. Finally, CRSP researchers developed a simple solar heater to kill cowpea bruchids and larvae prior to storage. This process consists of exposing the grain to sunlight on a black plastic sheet spread on a layer of an insulating material. This sheet is then covered with a clear plastic sheet folded on the edges to retain heat. The grain is then stored in a sealed container to prevent contamination.

The objective of the study on which this brief is based was to measure the economic impact of these storage technologies in Benin, Burkina Faso, Cameroon, Mali, Niger, Nigeria, and Senegal.

Methodology

The research was conducted in two steps. First, surveys were used to collect information from cowpea producers in each of the studied countries. Second, results of these surveys were combined with information collected from secondary data sources and used to generate the data inputs and parameters required to conduct a regional economic impact assessment, using economic surplus methods. To estimate the benefit attributable specifically to the postharvest technologies, the surplus approach was supplemented by a two-period storage model in which production takes place in only one period but farmers

have the option of selling their output at harvest (period 1) or storing all or part of their output and selling it at a later time (period 2). IRR and NPV were used to assess the economic impact. A sensitivity analysis was carried out on key parameters and assumptions to test the robustness of results.

Data

In each country, 10 villages located in major cowpea growing areas were randomly selected. Interviews were conducted with leaders in each of these villages. Within each village, 11 to 15 farmers were randomly selected for interview. A total of 795 farmers were interviewed between 2004 and 2005.

From these interviews, information regarding cowpea production and usage, cowpea storage techniques, the proportion of cowpea that was stored, costs associated with storage technology adoption and use, and the socioeconomic characteristics of cowpea producers was collected through village and household surveys in each country. Price data across time were obtained from several sources, including agricultural extension services, B/C CRSP survey data, and data from other institutions. Cowpea production quantities were obtained from agricultural extension services and FAO statistics. Other parameters were obtained from the literature.



Farmers in Pala, Chad, open bags and examine cowpeas stored using the triple bagging storage technique. Since 2007, the Purdue Improved Cowpea Storage (PICS) project has been disseminating this CRSP-developed storage technique in West and Central Africa. (Photo taken from PICS project's web site [*Purdue Agricultural Communication photo/Beksoubo Damienne*]).

Results

Adoption of storage technologies

The highest adoption rate in 2004 was found in Senegal, where metal drum technology was used to protect about 48 percent of stored cowpea grain. Nigeria had the second-highest adoption level, with the double-bagging technology used to protect about 23 percent of the stored cowpea. While bagging and metal drums were commonly used in several countries, the improved ash technology was mostly adopted in Burkina Faso, where ash was used to protect more than 13 percent of the stored cowpea. In most of the studied countries, the solar heater technique was rarely used to treat cowpea grain. Although many farmers reported the acquisition of clear plastic as the main constraint, other farmers argued that the traditional method of drying grain in the sunlight is very effective and were not convinced of the need or benefit of using solar heaters.

Farmers storing grain using traditional technologies frequently add insecticides to reduce grain losses due to infestation. The percentage of farmers who applied insecticide when using traditional storage methods ranged from 16 percent in Burkina Faso to 38 percent in Nigeria. Although using insecticide is not necessary when using CRSP technologies, in all of the countries in the study, some farmers used insecticides. Use of insecticide was more common among farmers who adopted the double bagging instead of the recommended triple bagging technique. Further, farmers applied insecticides when drums were not full.

Baseline results

The benefits were first estimated for each country and then aggregated to the regional level. Results in Table 1 indicate that, at the regional level, these technologies offer an estimated NPV of \$295 million (in 2000 USD) and an IRR of 28.6 percent. At a national level, the highest absolute returns were generated in Nigeria (NPV=\$199 million; IRR=53.7 percent), followed by Burkina Faso (NPV=\$38 million; IRR=132.3 percent) and Niger (NPV=\$28 million; IRR=54.4 percent). In contrast, the lowest returns were generated in Cameroon (NPV=\$1.5 million; IRR=8.3 percent). As could be anticipated, the lowest returns on investment were generated in the countries in which the storage research was conducted (due to research costs); an IRR of 16.9 percent was generated in Senegal and an 8.3 percent IRR was estimated for Cameroon.

The IRR generated through this project was compared to the cost of capital of West African governments, the formal private sector in this region, and, since the U.S. government was the major financier for this project, the U.S. government's cost of capital. Ghana's government bonds (adjusted for inflation) generated an interest rate of 8.9 percent and 5.4 percent in 2004 and 2005, respectively. These rates were used as references for other West African government capital returns. For the private sector, inflation-adjusted bank real lending rates, averaged for Cameroon and Nigeria for 1996–2005, yielded a real rate of return of about five percent. At the time of this CRSP investment, the return for investments in U.S. Treasury bonds was 4.8 percent. Thus, compared to any of these three alternatives, the CRSP storage program was a very good investment.

With regard to specific technologies, results indicate that the double and triple bagging technology generated the highest regional benefit, with a present value (PV) of \$162 million, followed by the metal drum technology (PV = \$133 million), and far behind, the improved ash technology (PV = \$17 million). At the country level, returns for the use of both double bagging and metal drum technologies were highest in Nigeria and were notable in Burkina Faso and Niger. In contrast, returns to the use of improved ash technology were concentrated in Burkina Faso and Mali.

Sensitivity analysis

Overall, the sensitivity analyses indicate that the baseline results are relatively robust (Table 2). However, the model proved to be relatively sensitive to

Table 1. Economic surplus results: baseline estimates including research and extension costs.

Country	Financial measure	
	Internal rate of return (%)	Net present value (year 2000 USD)
Benin	94.9	4,424,513
Burkina Faso	132.3	38,533,124
Cameroon ¹	8.3	1,470,139
Mali	88.4	15,201,388
Niger	54.4	27,764,733
Nigeria	53.7	198,917,911
Senegal ¹	16.9	9,057,581
Regional	28.6	295,369,390

¹ Cameroon and Senegal are the countries in which research costs were incurred; thus, the net returns are lowest.

Table 2. Results from baseline and sensitivity testing.

Measure	Baseline parameter value	Sensitivity test parameter value	IRR (%)	NPV (2000 USD)
Baseline			28.6	295,369,390
Sensitivity on Elasticity			28.9	294,740,744
Demand Period 1	5	10		
Demand Period 2	0.2-0.5	0.2-0.5		
Supply	0.08-0.24	0.2-0.5		
Sensitivity on Storage Loss				
a. Old technology loss rate	25%	50%	35.7	675,911,354
b. New technology loss rate	0.6%	1%	28.5	291,212,547
Sensitivity on Opportunity Cost of Capital				
a. Baseline	100%			
b. Opportunity cost of capital in developing countries		50%	23.3	152,046,890
c. Opportunity cost of capital in developed countries		10%	25.3	195,559,257
Sensitivity on Proportion of grain stored	70%	50%	32.9	509,753,845
Storage without insecticide use		Adoption of Pure CRSP Technology Only	25.2	243,540,210
Hermetic Storage only		Adoption of only Hermetic Improved Storage Methods	28.3	278,650,491

changes in parameters that characterize the extent of grain loss during storage using traditional techniques, the proportion of cowpea stored in period 1, and the opportunity cost of capital.

Conclusions

The development and dissemination of improved, non-chemical storage technologies has been a major initiative of the B/C CRSP, NGOs, and the extension services of several African nations. Overall, it is estimated that approximately 30 percent of grain in the countries studied is stored using the CRSP-developed double and triple bagging or closed metal drum storage techniques. Although insecticides are not needed with hermetic storage techniques, many farmers reported using insecticides as additional insurance against infestation. Use of the improved ash storage method was concentrated in Burkina Faso, Mali, and

Cameroon, and is used to store only a small quantity of grain (approximately one percent of regional production). Adoption of solar heaters was limited to a few villages in Cameroon and Burkina Faso.

The IRR was found to be substantially greater than the cost of capital for the recipients' countries and the principal donor for all the countries where farmers are currently using CRSP's storage technologies. Country-level returns were estimated to be highest for Burkina Faso (132 percent), Benin (95 percent), and Mali (88 percent). At the regional level, the IRR was estimated to be 28.6 percent and the NPV for 1982 to 2020 was estimated at more than \$295 million USD. The results proved to be robust under sensitivity testing.

About this brief

This brief is based on the study by B. Moussa, J. Lowenberg-Deboer, J. Fulton, and K. Boys (2011) entitled "The economic impact of cowpea research in West and Central Africa: A regional impact assessment of improved cowpea storage technologies," *Journal of Stored Products Research* 47:147-156. The US Agency for International Development provided financial support for this research under Grant No. CR-9084-425215 entitled "Economic Impact of Cowpea Storage Technology in Senegal," and Grant No. GDG-G-00-02-00012-00 (Bean/Cowpea CRSP).

B. Moussa (bmoussa@purdue.edu) is a researcher at the National Institute for Agricultural Research of Niger (INRAN); J. Lowenberg-Deboer (lowenbej@purdue.edu) and J. Fulton (fultonj@purdue.edu) are faculty members at Purdue University; and K. Boys (kboys@vt.edu) is a faculty member at Virginia Tech University.

Photos contributed by B. Moussa and taken from PICS project's web site (Photographer: Beksoubo Damienne).

Special thanks go to B. Reyes and M. Maredia for the design of this brief and to M. Halversen for her edition of this brief.