# Evaluating the Effectiveness of Alternative Extension Methods: Triple-Bag Storage of Cowpeas by Small-Scale Farmers in West Africa

**Bokar Moussa**
**Graduate Research Assistant**
**Department of Agricultural Economics**
**Purdue University**
**bmoussa@purdue.edu**

**Miriam Otoo**
**Graduate Research Assistant**
**Department of Agricultural Economics**
**Purdue University**
**motoo@purdue.edu**

**Joan Fulton**
**Professor**
**Department of Agricultural Economics**
**Purdue University**
**fultonj@purdue.edu**

**James Lowenberg-DeBoer**
**Associate Dean for International Programs in Agriculture and**
**Professor of Agricultural Economics**
**Purdue University**
**lowenbej@purdue.edu**

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## Abstract

This study examined two questions related to the adoption of triple-bag storage technology for farmers storing cowpeas in West Africa. First the effect of an extension program, focused on village demonstrations, on adoption was considered. Second, the effect of radio messages to augment this extension program was analyzed. The results indicate that adoption was positively affected by the extension program and radio messages do augment the effectiveness.

## I. Introduction

In Africa agricultural research has developed techniques to improve crop and livestock production and post-harvest handling, but many of those innovations stay on the shelf. They do not reach farmers and the impact of the new innovations or techniques is not realized. A recently awarded project from the Bill and Melinda Gates Foundation recognized the importance of extension methods in the effort to spread the use of improved storage techniques for cowpeas (known as black-eyed peas in the US) among the millions of small scale farmers in 10 countries in West Africa. Cowpeas are one of the most important crops for West African farmers because cowpeas can survive the harsh and arid growing conditions. They are used as food for the farmers' families as well as sold for much needed cash in the market. Because cowpeas are very susceptible to damage from weevils during storage West African farmers are often obliged to sell their product right after the annual harvest. The innovation explored here is storage in air tight (hermetic) triple layer bags that eliminate damage from the weevils by restricting the oxygen supply to the insects. The adoption of triple-bag storage for their cowpeas would allow farmers to safely store their product and realize the higher prices available later in the market year, that are consistent with a storable commodity. Although the effectiveness of hermetic storage and in particular triple-bag storage for cowpeas has been known for about 20 years, wide-spread adoption has not occurred because farmers were not generally aware of the technology or did not understand how to implement the technology. The Purdue Improved Cowpea Storage project (PICS) was established to solve this problem. Given the need to reach a large number of farmers over a vast geographic region it is important to utilize the most effective extension methods.

Little attention has been paid to evaluating alternative extension approaches, especially in the context of West Africa. Most recent work has dealt more directly with the adoption of new

technologies rather than the medium of transferring or facilitating adoption. Adeoti et al. (2002) estimated the adoption of new cowpea technologies including improved varieties, plant extracts and improved storage techniques, in eight countries of West Africa. The objective of that study was to estimate adoption rates not to evaluate the effectiveness of alternative extension methods. Kristjanson et al. (2005) used different research approaches to examine the adoption and impact issues related to improved varieties of dual-purpose cowpea. That article focused on factors affecting the adoption and impact of the technology across different socio-economic domains but did not evaluate the extension methods. Bindlish and Evenson (1997) evaluated the impact of one single extension method, the training and visit (T&V) extension method, in Africa but the effectiveness of the method was evaluated based on descriptive analysis only.

The objective of our paper is to evaluate the effectiveness of alternative extension methods that were deliberately incorporated into the first year of the project. The core of this extension program focused around village level demonstrations of the triple-bag storage technology. For the first year of the project about one-half of the villages received the core program while the second half of the villages received radio announcements in the local language that specifically targeted the local farmer population to augment the core program of village level demonstrations. The following section of the paper describes the structure of the research, the data collected and the analysis used. The empirical results are then presented. The final section of the paper contains conclusions and suggestions for further study.

## II. Data and Methodology

The PICS project was structured with pilot activity in the first year in the two countries of Burkina Faso and Niger to evaluate the alternative extension methods. The core extension program focused on the village level demonstration of the triple-bag storage technology and involved multiple village contacts by a trained technician. The technician began with a sensitization visit to the village at which time he/she met with the village chief and other leaders of the village. During that meeting the technician explained how the triple-bag storage technology works and how it would benefit the farmers. The purpose of this sensitization visit was to explain the technology, obtain commitment for the village to participate in the program and set up the date/time for the village demonstration. The second point of contact was the demonstration of the triple-bag storage technology soon after cowpea harvest. The demonstration was structured as a public event in the village with everyone gathering in a central location. The technician began the demonstration by explaining two key concepts. The first concept dealt with the fact that the triple-bag storage of cowpeas worked because once the cowpeas are in an air-tight environment there is no oxygen for the weevils and without oxygen the weevils will die. The second key concept related to the financial gain that the farmers could experience from selling their cowpeas later in the season after the price increased. An integral part of the village demonstration was first-hand experience by the farmers. In each village between 5 and 10 farmers, who were often leaders in the community, brought their cowpea and filled the storage bags as part of the demonstration. During this part of the village demonstration the technician observed while the farmers filled and closed up the bags. When appropriate the technician provided advice but allowed the farmers to do the filling of the bags. The program was structured this way to take advantage of the fact that people remember more of what they learn when they

are actually able to do it themselves. In the months following the demonstration the technician would visit the village and hold informal meetings with the village leaders and other farmers. The technician would inquire about the bags of cowpeas and remind the villagers of how the value of their cowpeas was increasing as the price of cowpeas in the market was going up. In addition, he/she would remind them that it was necessary to keep the bags closed because if oxygen is allowed into the bag the weevils will damage the cowpeas. Between four and six months after harvest a second demonstration, open to all in the village, takes place. The technician returns to the village for the Open-the-Bag demonstration where the farmers who filled the bags of cowpeas at the first demo then open the bags in front of the whole group to find that the cowpeas are in the same condition as when the bags were filled. As part of this demonstration the technician takes advantage of the "teachable moment" and he/she explains once again the two key concepts related to the financial gain resulting from selling at a higher price and how the lack of oxygen causes the weevils to die.

The second extension method involved the core program as described above and also included radio messages broadcast to the villagers. Radio is the most widely used medium of mass communication in West Africa. Most rural people in the region do not have access to television. Radio broadcasts occur in many local languages, so information does not depend on knowledge of an official language (e.g. English, French) and does not depend on literacy. In this paper we first evaluate the effect of the core extension program on adoption of the triple-bag storage technology by the farmers. Next, we examine whether the addition of radio messages to augment the village demonstration program is effective in increasing the level of adoption.

Data were collected in two countries, Burkina Faso and Niger, in the spring of 2008. The village level demonstrations of the storage technology had taken place beginning in November

2007. Table 1 reports the distribution of villages surveyed for each country. Data were collected from villages that received the core extension program, labeled as Villages receiving Demonstrations only, villages that received the core extension program and radio announcements, labeled as Villages receiving Demonstrations with Radio, and villages that did not receive the extension program, labeled as Control Villages. In Burkina Faso 43 villages received the core extension program and 48 villages received the core extension program augmented with radio. In Niger 56 villages received the core extension program and 40 villages received the core extension program with radio. Less than half of the villages in Niger had radio as part of their program due to problems associated with getting contracts set up between local partners and the radio stations.

Table 1: Distribution of Villages Surveyed

| | **Niger** | | **Burkina Faso** | |
|---|---|---|---|---|
| | Number | Percentage (%) | Number | Percentage (%) |
| Villages receiving Demonstrations with Radio | 40 | 36 | 48 | 48 |
| Villages receiving Demonstrations only | 56 | 50 | 43 | 43 |
| Control villages | 15 | 14 | 9 | 9 |

Data were collected by way of personal interviews with farmers. In each of the control villages 10 farmers were randomly selected and interviewed. In the villages that were part of the extension program five farmers whose cowpea was used in the demonstration were interviewed and five additional farmers were randomly selected and interviewed. In total, over 1000 farmers were interviewed in the 211 villages in the two countries.

## III. Descriptive Statistics

### Niger

Descriptive statistics for key variables are presented in Tables 2 and 3. In Niger the average age of the farmers who were interviewed was 43 years with an average household size of 10 people. The standard deviations are 12.9 and 5.4 respectively suggesting wide variation across respondents. To obtain some idea of the potential for farm productivity by household, respondents were asked about the number of working-age men and number of working-age women in their household, which is two workers per household for both men and women. In terms of the quantity of cowpea stored and sold at harvest, on average farmers currently store more than 100kg and sell slightly less than 100kg. This result suggests that on average each farmer will need one 100kg PICS bag to store cowpea at harvest. On the other hand we can also argue that each farmer would have avoided selling his/her cowpea at harvest if he/she had the PICS bag to properly store his/her cowpea. It is important to note that the standard deviation is high in both cases. The data varies from 0 to more than 3300 kg and 0 to 2500 kg for the quantity stored and sold respectively.

Of the respondents, 10% are women. Farmers surveyed are from three ethnic groups. The majority of the respondents are Haussa (65%), followed by the Kanuri (31%). The Touareg group represents only 4% of the sample as one could expect. The Touareg group is traditionally nomadic and is still more involved in livestock production than crop production. Twenty-four percent of the respondents indicated that they had no education and only 19% indicated they had even some formal education.

Respondents were also asked to report the storage methods they used for their cowpea prior to 2007. Over half of the respondents indicated they were using traditional storage methods.

Thirty percent of the respondents affirm using double or triple-bag technology before the PICS program. Steel drums can be effective for hermetic storage of cowpeas and were used by 15% of the respondents. It is interesting to note that for both technologies the percentage of hermetic storage use is far higher than measured by Moussa (2006). The high level of use (50%) of insecticide is also expected and suggests the pressing need for better storage methods. Moussa (2006) found that insecticides were often used with hermetic storage for insurance, because farmers were not confident that hermetic storage alone would control insects. In terms of involvement in the PICS information dissemination program three categories of farmers were interviewed: 41% of the respondents took active participation in the program by having their cowpea used for the village demonstration, 40% attended the demonstration or heard about it and only 19 neither attended nor heard about the program. This last category is mainly from the control villages.

**Burkina Faso**

The average age of the respondent and household size is very similar to Niger at 42 years and 10 people respectively. Once again the standard deviations are high at 12.1 and 5.6 respectively suggesting wide variation across respondents. The number of working-age men and working-age women was three, slightly larger than in Niger. On average the respondents reported storing over 200 kg of cowpea at harvest and selling just over 50kg of cowpea.

The majority of the respondents belong to the Mossi ethnic group (60%); followed by the Samo ethnic group (20%) and then the Peulh ethnic group (20%). Sixty percent of the respondents were male. Seventy percent of the respondents engage solely in farming as their income-generating activity, with 30% of respondents involved in multiple income-generating activities. With respect to the types of storage technologies used prior to 2007, 73% of the

Table 2: Descriptive Statistics of Characteristics of Respondents (Continuous Variables)

| Variables | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| **Niger** | | | | |
| Age | 42.8 | 12.9 | 15.0 | 95.0 |
| Number of Children | 5.9 | 3.8 | 0.0 | 28.0 |
| Number of Working-Age Males in Household | 2.1 | 1.8 | 0.0 | 21.0 |
| Number of Working-Age Females in Household | 2.1 | 1.7 | 0.0 | 21.0 |
| Total Size of Household | 10.0 | 5.4 | 1.0 | 39.0 |
| Quantity of Cowpea Stored at Harvest (kg) | 122.9 | 218.8 | 0.0 | 3300.0 |
| Quantity of Cowpea Sold at Harvest (kg) | 77.9 | 160.2 | 0.0 | 2500.0 |
| **Burkina Faso** | | | | |
| Age | 42.0 | 12.1 | 17.0 | 80.0 |
| Number of Children | 4.0 | 2.9 | 0.0 | 36.0 |
| Number of Working-Age Males in Household | 3.0 | 2.0 | 0.0 | 12.0 |
| Number of Working-Age Females in Household | 3.0 | 2.9 | 0.0 | 15.0 |
| Total Size of Household | 10.0 | 5.6 | 1.0 | 42.0 |
| Quantity of Cowpea Stored at Harvest (kg) | 221.8 | 13.4 | 0.0 | 8000.0 |
| Quantity of Cowpea Sold at Harvest (kg) | 51.3 | 7.5 | 0.0 | 10000.0 |

Table 3: Descriptive Statistics of Characteristics of Respondents (Discrete Variables)

| | **Niger** | | **Burkina** | |
|---|---|---|---|---|
| Variables | Freq. | % | Freq. | % |
| **Gender** | | | | |
| Male | 990 | 90 | 811 | 60 |
| Female | 87 | 10 | 589 | 40 |
| **Ethnic Group**[1] | | | | |
| Kanuri /Mossi | 337 | 31 | 817 | 60 |
| Haussa /Samo | 699 | 65 | 316 | 20 |
| Touareg/Peulh | 39 | 4 | 269 | 20 |

[1] This refers to the ethnic groups described in Table 1. (Kanuri, Haussa and Touareg for Niger; and Mossi, Samo and Peulh for Burkina Faso).

| | | | | |
|---|---|---|---|---|
| **Education**[2] | | | | |
| No Education | 255 | 24 | 589 | 42 |
| Some Formal Education | 209 | 19 | 286 | 20 |
| Some Informal Education | 754 | 70 | 700 | 50 |
| | | | | |
| **Association Membership** | | | | |
| Not Member | 147 | 10 | 484 | 30 |
| Member | 854 | 90 | 911 | 70 |
| | | | | |
| **Contact with any Extension Service** | | | | |
| No contact with extension | 244 | 20 | 626 | 40 |
| Contact with extension | 815 | 80 | 772 | 60 |
| | | | | |
| **Activity** | | | | |
| Agriculture and non agricultural activity | 923 | 90 | 365 | 30 |
| Agriculture Only | 153 | 10 | 1037 | 70 |
| | | | | |
| **Use of Technology Prior to 2007**[3] | | | | |
| Traditional Method | 574 | 53 | 1023 | 73 |
| Insecticides | 539 | 50 | 471 | 34 |
| Double or Triple-Bag | 325 | 30 | 317 | 23 |
| Metal Drum | 166 | 15 | 138 | 10 |
| | | | | |
| **Level of Involvement in PICS Demonstration Project** | | | | |
| No Involvement (NP) | 199 | 19 | 719 | 51 |
| Attended Village Level Demonstration as Observer | 414 | 40 | 272 | 20 |
| Active Participant in Village Level Demonstration by having his/her cowpea used in demo | 432 | 41 | 408 | 29 |
| | | | | |
| **Use of Triple-Bag Technology** | | | | |
| Did not use triple-bag in 2007 | 613 | 60 | 903 | 70 |
| Did use triple-bag in 2007 | 464 | 40 | 482 | 30 |

[2] The sum of the percentages for the different categories of educational levels is more than 100% for both Niger and Burkina Faso because respondents were asked to check all entries that apply.

[3] The sum of the percentages for the different categories of types of technology use is more than 100% for both Niger and Burkina Faso because respondents were asked to check all entries that apply.

respondents reported using traditional methods. Cowpea farmers in Burkina Faso use traditional storage methods such as: jugs with and without sand or ash and sealed plastic or glass bottles. Thirty-four percent of the respondents reported using insecticides, while 23% used double or triple-bag and 10% used metal drums.

## IV. Empirical Results for the Logistic Analysis

The dependent variable used in the analysis is whether the respondent adopted the triple-bag storage for cowpeas and is coded as "1" if the respondent did use the PICS triple-bag technology and "0" otherwise. Binary logit analysis was used to evaluate the factors affecting adoption with particular interest in the effectiveness of extension programs. Independent variables also include the farmer characteristics of age, gender, farm size, household size, and farm diversification. The first analysis will address the question of whether an extension program influences adoption and will include a dummy variable for whether the farmer came from a control or a PICS program village. The second analysis will address the question of whether the use of radio, to augment the core extension program influences adoption. In the second round of analysis only data from the villages involved in the extension program will be used and a dummy variable for whether the farmer came from a radio village will be included as an independent variable.

Table 4: Identification of Variables Used in the Model

| Variable | Description |
|---|---|
| USETECH | Dummy variable equal to one if respondent used the triple-bag technology in 2007 and zero otherwise |
| VIL_DEMO | Dummy variable equal to one if any form of extension program was used in the village and zero otherwise |
| PP | Dummy variable equal to one if respondent was a participant in PICS village level demonstration and zero otherwise |
| NP | Dummy variable equal to one if respondent had no involvement in the PICS village level demonstration and zero otherwise |
| SEX | Dummy variable equal to one if respondent was male and zero if female |
| AGE | Age of respondent |
| MOSSI | Dummy variable equal to one if respondent is of the Mossi ethnic group and zero otherwise |
| SAMO | Dummy variable equal to one if respondent is of the Samo ethnic group and zero otherwise |
| PEULH | Dummy variable equal to one if respondent is of the Peulh ethnic group and zero otherwise |
| KANURI | Dummy variable equal to one if respondent is of the Kanuri ethnic group and zero otherwise |
| HAUSSA | Dummy variable equal to one if respondent is of the Haussa ethnic group and zero otherwise |
| TOUAREG | Dummy variable equal to one if respondent is of the Touareg ethnic group and zero otherwise |
| CHILD | Number of children in household |
| WORKM | Number of working-age males in household |
| WORKW | Number of working-age females in household |
| HHSIZE | Total number of individuals in household |
| CONTEXT | Dummy variable equal to one if respondent had any contact with any source of extension service and zero otherwise |
| ASSOC | Dummy variable equal to one if respondent was a member of a farmer's association and zero otherwise |
| ACTIVITY | Dummy variable equal to one if respondent's source of income is from agricultural activity only and zero otherwise |
| STORHARV | Quantity of cowpea stored at harvest in 2007 (kilograms) |
| SOLDHARV | Quantity of cowpea sold at harvest in 2007 (kilograms) |
| DBLETRPL | Dummy variable equal to one if respondent used double and/or triple-bag storage technology prior to 2007 and zero otherwise |
| DRUM | Dummy variable equal to one if respondent used drum storage technology prior 2007 and zero otherwise |
| TRADTECH | Dummy variable equal to one if respondent used traditional storage technology prior 2007 and zero otherwise |
| INSECT | Dummy variable equal to one if respondent used insecticides as storage technology prior 2007 and zero otherwise |

**a) Results for Binary Logit Regression Analysis for Niger (Effects of the PICS extension program).**

Results of the triple-bag technology adoption are reported in Tables 5 and 6 to address the two questions considered in this paper. Table 5 presents the effects of the PICS extension program on the adoption of the triple-bag technology. The analysis reported in Table 5 used observations from the villages that had no extension program (control villages) and the villages that received the PICS extension program. Table 6 reports the results of the analysis involving only the villages that received a PICS extension program and considers the question of whether radio announcements to augment the village demonstrations were effective for increasing adoption. Likelihood ratio test statistics for both analyses indicate that all models are statistically significant at the 99% level.

The coefficients for the variable, VIL_DEMO, which captures the impact of having a PICS extension program in the village, are positive and statistically significant for all models. This suggests that the PICS extension program has a positive effect on the probability of adoption. Furthermore, farmers who participated directly in the demonstrations by offering their cowpea and those who just attended and/or heard about these events, have a higher probability of adopting the triple- bag technology compared to those who did not attend or hear about these activities. This effect is captured by the variable, PP. This result is consistent with previous studies finding by Adesina et al. (2000) and Ramji et al. (2002).

In addition to the positive effect of extension programming on adoption, some of the household characteristics are statistically significant with the expected signs. We observe that the probability of adopting is greater for female farmers compared to male farmers. The variable, AGE has the expected negative sign and is statistically significant, indicating that adoption is

lower among older farmers. This result is consistent with the literature. Household size is also significant with the expected sign. Larger households are also more likely to adopt the triple-bag technology, mainly because they can produce more cowpea and therefore store more. The number of the working men (WORKM) is not statistically significant.

Prior exposure to technical information also plays an important role in increasing the probability of adopting the triple-bag technology. Farmers who have had previous contact with either extension services, NGOs or development projects in agriculture programs (CONTEXT) are more likely to have used PICS bags in 2007 compared to the farmer respondents without extension contacts. One possible explanation is that when extension contact is successful, farmers develop more trust in the new technology. Adeogun et al. (2008) found a similar result that being exposed to information from trusted sources can stimulate adoption. Membership in village associations seems not to influence the adoption of the triple-bag technology. In Niger, the associations are not well developed and when they exist there are not very active. In general only the board members are fully involved and act on the behalf of all members in all occasions. For example, meetings where information can be exchanged with all members are rare.

The dummies for the storage technologies used before 2007, DBLETRPL, TRADTECH and DRUM are not statistically significant. The dummy for the insecticide variable is statistically significant with the expected positive sign. Farmers who used insecticides prior to 2007 would be more likely to adopt the triple-bag technology. Quantity stored at harvest (STORHARV) is statistically significant. For the quantity stored at harvest a positive sign means that producers who store more at harvest are more likely to adopt the triple-bags perhaps because they are in more need of good storage methods. The quantity sold at harvest is not statistically significant but has the expected positive sign.

Table 5: Binary Logit Estimates for Effect of PICS Extension program on the Adoption of Triple-Bag Technology for Niger

| **Variables** | **Model 1** | **Model 2** | **Model 3** |
|---|---|---|---|
| VIL_DEMO | 3.958*** | 3.995*** | 3.811*** |
| | (1.040) | (1.040) | (1.031) |
| PP | 3.008*** | 2.994*** | 2.898*** |
| | (0.417) | (0.415) | (0.396) |
| SEX | -3.134*** | -3.150*** | -3.142*** |
| | (0.591) | (0.589) | (0.579) |
| AGE | -0.024*** | -0.025*** | -0.024*** |
| | (0.008) | (0.008) | (0.008) |
| KANOURI | -0.278 | -0.279 | -0.002 |
| | (0.639) | (0.639) | (0.625) |
| HAOUSSA | -0.288 | -0.299 | -0.335 |
| | (0.611) | (0.610) | (0.600) |
| WORKM | 0.123 | 0.121 | 0.114 |
| | (0.076) | (0.076) | (0.075) |
| HHSIZE | 0.054** | 0.054** | 0.069*** |
| | (0.022) | (0.022) | (0.022) |
| CONTEXT | 0.983*** | 0.981*** | 1.019*** |
| | (0.262) | (0.262) | (0.255) |
| ASSOC | 0.480 | 0.473 | 0.434 |
| | (0.307) | (0.307) | (0.301) |
| ACTIVITY | 0.005 | 0.021 | -0.115 |
| | (0.290) | (0.289) | (0.287) |
| STORHARV | 0.003*** | 0.003*** | |
| | (0.001) | (0.001) | |
| SOLDHARV | 0.000 | | 0.000 |
| | (0.000) | | (0.001) |
| DBLETRPL | 0.004 | -0.002 | 0.076 |
| | (0.247) | (0.247) | (0.244) |
| DRUM | -0.146 | -0.155 | -0.218 |
| | (0.314) | (0.314) | (0.308) |
| TRADTECH | -0.028 | -0.038 | -0.040 |
| | (0.206) | (0.205) | (0.203) |
| INSECT | 0.568*** | 0.567*** | 0.506** |
| | (0.224) | (0.224) | (0.218) |
| CONSTANT | -4.970*** | -4.958*** | -4.527*** |
| | (1.384) | (1.386) | 1.357 |
| Likelihood ratio statistic | -407.45*** | -407.62*** | -421.41*** |
| Pseudo $R^2$ | 0.390 | 0.390 | 0.369 |

[a] Values in parenthesis below the coefficients represent Standard Errors

* Indicates statistically significant at 90 percent level

** Indicates statistically significant at 95 percent level

*** Indicates statistically significant at 99 percent level

**b) Results for Binary Logit Regression Analysis for Niger (Effects of Using Radio Messages to augment the extension program).**

Another important aspect in the evaluation of the extension methods is to study the additional effect of the radio announcements to augment the program focused around demonstration activities. Table 6 reports the results of analysis using data from the villages that received PICS demonstrations with a dummy variable included for those villages that also received radio messages.

The variable VILR is positive in all models and statistically significant in model 3, indicating that the radio messages have an additional positive impact on the adoption of the triple-bag technology compared to the demonstration-only program.

Table 6: Logit Estimates of the Effects of Radio Messages on the Adoption of Triple-Bag Technology for Niger without Control Villages

| **Variables** | **Model 1** | **Model 2** | **Model 3** |
|---|---|---|---|
| VILR | 0.713 | 0.719 | 1.180** |
| | (0.571) | (0.569) | (0.528) |
| PP | 3.251*** | 3.230*** | 3.175*** |
| | (0.449) | (0.445) | (0.429) |
| SEX | -3.113*** | -3.137*** | -3.110*** |
| | (0.606) | (0.604) | (0.597) |
| AGE | -0.026*** | -0.026*** | -0.025*** |
| | (0.008) | (0.008) | (0.008) |
| KANURI | -0.526 | -0.524 | -0.381 |
| | (0.689) | (0.686) | (0.680) |
| HAUSSA | 0.094 | 0.086 | 0.334 |
| | (0.730) | (0.727) | (0.708) |
| WORKM | 0.125 | 0.123 | 0.111 |
| | (0.077) | (0.077) | (0.076) |
| HHSIZE | 0.056*** | 0.057*** | 0.072*** |
| | (0.022) | (0.022) | (0.022) |
| CONTEXT | 0.986*** | 0.983*** | 1.026*** |
| | (0.262) | (0.262) | (0.256) |
| ASSOC | 0.515 | 0.505 | 0.496 |
| | (0.310) | (0.310) | (0.303) |
| ACTIVITY | 0.038 | 0.063 | -0.057 |
| | (0.292) | (0.290) | (0.289) |
| STORHARV | 0.003*** | 0.003*** | |
| | (0.001) | (0.001) | |
| SOLDHARV | 0.000 | | 0.000 |
| | (0.000) | | (0.000) |
| DBLETRPL | 0.026 | 0.018 | 0.128 |
| | (0.250) | (0.250) | (0.247) |
| DRUM | -0.138 | -0.153 | -0.204 |
| | (0.315) | (0.314) | (0.309) |
| TRADTECH | -0.001 | -0.018 | -0.001 |
| | (0.207) | (0.206) | (0.205) |
| INSECT | 0.606*** | 0.604*** | 0.569*** |
| | (0.226) | (0.226) | (0.221) |
| CONSTANT | -1.717 | -1.648 | -1.842 |
| | (1.164) | (1.158) | (1.126) |
| Likelihood ratio statistic | -399.87*** | -400.26*** | -412.40*** |
| Pseudo $R^2$ | 0.266 | 0.266 | 0.243 |

[a] Values in parenthesis below the coefficients represent Standard Errors

* Indicates statistically significant at 90 percent level

** Indicates statistically significant at 95 percent level

*** Indicates statistically significant at 99 percent level

### c) Results for Binary Logit Regression Analysis for Burkina Faso (Effects of the PICS extension program)

Table 7 shows the results of the binary logit analyses where we test the effect of the PICS extension program on the adoption of the triple-bag technology. Likelihood ratio test statistics indicate that all models are statistically significant at the 99% level. As expected, the coefficient for VIL_DEMO is positive and statistically significant for all models. This suggests that a farmer from a village where the PICS extension program was used as an information dissemination tool has a higher probability of adopting the triple-bag technology than a respondent from a control village (i.e. a village with no extension programs). This is consistent with the findings of Doss et al. (2003) who found that the extension programs are valuable tools in increasing the probability of technology adoption in Africa.

In all the models, we observe that the coefficients for PP are positive and statistically significant. These results indicate that farmers who participated in the PICS village level demonstrations were more likely to adopt the triple-bag technology than those who had no involvement in the village level demonstrations. This confirms the conclusions of Adesina et al. (2000) and Ramji et al. (2002), which support the idea that active participation or attendance in field demonstrations has a significant impact on the adoptability of technology particularly in developing countries.

Variables associated with the personal characteristics of the respondents such as SEX and AGE were found to be statistically insignificant. This suggests that the age and gender of the farmer did not influence their decision in the adoption of the triple-bag technology. Interestingly, the negative sign of the AGE coefficient confirms results from a study by Chianu and Tsujii, (2004) that showed that compared with younger farmers, the probability of adopting technology

is lower among older farmers in part because of their shorter planning horizons. However, the coefficients representing the ethnicity of a farmer, MOSSI, were positive and statistically significant for all models. This implies that a farmer of the Mossi ethnic group were more likely to adopt the storage technology than a farmer of the reference group, PEULH. Burkinabés of the Peuhl ethnic group are traditionally nomads, engaging predominantly in livestock-rearing. Agricultural production by the Peuhl group is often limited to the cultivation of cereal grains on small parcels of land during their migration (FAO, 2009). Given that cowpea production is relatively small and mainly for purposes of household and animal consumption, it makes intuitive sense that the Peulhs would be less likely to store their cowpea grains and thus, adopt the triple-bag technology. On the other hand, the SAMO coefficient was positive but statistically insignificant.

Coefficients for WORKM and HHSIZE are not statistically different from zero, indicating that the number of working-age males and the size of the household have no statistically significant impact in motivating farmers to adopt the storage technology. Parallel results are observed for the variable, ASSOC, which represents farmers that are members of a farmer's association. The CONTEXT variable, denoting a farmer that had contact with some source of extension service had the expected positive sign and was statistically significant. This substantiates the findings of Adeogun et al. (2008) and Doss et al (2003). They found that exposing farmers to information, particularly from trusted sources such as extension services can significantly motivate the adoption of technology.

Respondents engaging only in farming activities, represented by the ACTIVITY variable, were found to be less likely to adopt the triple-bag technology in comparison to those that engaged in multiple activities such as small-scale agro-processing and livestock-rearing. This

may suggest that farmers with limited sources of income and production opportunities are more likely to sell their cowpea grains at harvest for cash than store them, and thus, these farmers have lower probabilities of adopting the triple-bag technology. These results affirm Adesina and Zinnali's (1993) assertion that resource endowment plays an important role in observed adoption behavior.

The variable associated with the storage of cowpea, STORHARV is positive and statistically significant for models 1 and 2. This indicates that farmers who store more cowpea grains at harvest are more likely to adopt the triple-bag technology. Farmers with higher production levels may have more resources and a higher need of good storage methods and thus, are more likely to adopt the triple-bag technology. Though insignificant, the coefficient, SOLDHARV is negative for models 1 and 3. If farmers sell the majority of their production at harvest, they have very little incentive to adopt the triple-bag storage technology.

Coefficients for the variables measuring the use of different storage technologies prior to 2007, DRUM, TRADTECH and INSECT are positive and statistically significant for all the models. These results imply that the respondents who used steel drums, traditional methods and insecticides as storage technologies were more likely to adopt the triple-bag technology than those who did not use the respective technologies. These farmers may possibly be on the search for improved storage techniques and are thus, more likely to use the triple-bag technology if available. It is interesting to note that INSECT is positive and statistically significant indicating that those farmers who reported using insecticide are more likely to adopt the triple-bag technology. There has been increased awareness of health risks associated with insecticide use which may be the factor driving farmers' search for alternative storage technologies.

Table 7: Binary Logit Estimates for Effect of PICS Extension program on the Adoption of Triple-Bag Technology for Burkina Faso

| **Variables** | **Model 1** | **Model 2** | **Model 3** |
|---|---|---|---|
| VIL_DEMO | 1.641*** | 1.616*** | 1.680*** |
| | (0.376) | (0.375) | (0.376) |
| PP | 2.939*** | 2.924*** | 2.930*** |
| | (0.185) | (0.183) | (0.184) |
| SEX | 0.132 | 0.117 | 0.155 |
| | (0.160) | (0.159) | (0.159) |
| AGE | -0.001 | -0.0002 | 0.0005 |
| | (0.007) | (0.007) | (0.007) |
| MOSSI | 0.824*** | 0.801*** | 0.878*** |
| | (0.219) | (0.217) | (0.218) |
| SAMO | -0.305 | -0.341 | -0.379 |
| | (0.318) | (0.317) | (0.318) |
| WORKM | -0.044 | -0.048 | -0.051 |
| | (0.062) | (0.062) | (0.062) |
| HHSIZE | 0.020 | 0.018 | 0.027 |
| | (0.022) | (0.022) | (0.022) |
| CONTEXT | 1.228*** | 1.246*** | 1.231*** |
| | (0.190) | (0.190) | (0.190) |
| ASSOC | -0.169 | -0.192 | -0.175 |
| | (0.184) | (0.183) | (0.184) |
| ACTIVITY | -0.928*** | -0.944*** | -0.983*** |
| | (0.268) | (0.268) | (0.267) |
| STORHARV | 0.0004** | 0.0003** | |
| | (0.0002) | (0.0001) | |
| SOLDHARV | -0.001 | | -0.001 |
| | (0.001) | | (0.0009) |
| DBLETRPL | 0.183 | 0.204 | 0.086 |
| | (0.254) | (0.253) | (0.249) |
| DRUM | 0.503** | 0.506** | 0.527** |
| | (0.257) | (0.257) | (0.256) |
| TRADTECH | 0.506** | 0.497** | 0.466** |
| | (0.227) | (0.227) | (0.226) |
| INSECT | 0.371* | 0.356* | 0.398* |
| | (0.222) | (0.222) | (0.222) |
| CONSTANT | -5.093*** | -5.028*** | -5.083*** |
| | (0.591) | (0.587) | (0.590) |
| Likelihood ratio statistic | 677.27*** | 675.22*** | 672.01*** |
| Pseudo $R^2$ | 0.373 | 0.3714 | 0.370 |

[a] Values in parenthesis below the coefficients represent Standard Errors

* Indicates statistically significant at 90 percent level

** Indicates statistically significant at 95 percent level

*** Indicates statistically significant at 99 percent level

Another variable related to technology use, DBLETRPL, had a positive coefficient, but was statistically insignificant; suggesting that prior use of double-bag storage technologies will neither favor nor inhibit adoption of the new triple-bag technology. Though insignificant, the expected positive sign may imply that farmers' experience with the double-bag storage technology (less robust sacks) was positive enough that it may encourage them to use the triple-bag storage technology.

**d) Results for Binary Logit Regression Analysis for Burkina Faso (Effects of Using Radio Messages to augment the extension program).**

Results from Table 7 indicate that the PICS extension program has a positive influence on the adoption of the triple-bag technology in Burkina Faso. We, thus, further investigate in Table 8 the question about whether radio messages are useful as a tool to augment the effectiveness of the village demonstrations. Likelihood ratio test statistics indicate that all models are statistically significant at the 99% level. This analysis differs from the analysis in Table 7 in that to capture the effects of the addition of radio messages to the village demonstrations, data from the control villages are dropped so the analysis is for all farmers who were in a village that had a PICS demonstration.

Our variable of focus is VILR which denotes a farmer from a village where both village level demonstrations and radio messages are used as information dissemination methods. This variable is equal to one if radio messages were broadcast in that village and zero otherwise. The coefficient on this variable is positive and statistically significant. This implies that a farmer from a radio village has a higher probability of adopting the triple-bag technology than a farmer from a village where only village demonstrations were used as an extension method and no radio

messages were broadcast. This supports the hypothesis that radio messages are instrumental in increasing the efficiency of village level demonstrations.

The signs and significance of the coefficients for PP, MOSSI, CONTEXT, ACTIVITY, STORHARV and INSECT are parallel to those in Table 7. The implications of these results follow the same reasoning as elaborated for the findings in Table 7. The few exceptions related to the results in Table 8 are the significance of the SAMO and DBLETRPL variables. The positive sign and significance of the SAMO variable, indicates that a farmer of the SAMO ethnic group has a higher probability of adopting the triple-bag technology than the reference group, Peulh farmers. The coefficient for DBLETRPL, denoting farmers that used the double-bag storage technology prior to 2007, is positive and statistically significant. This may suggest that the experience of double-bag storage technology (less robust sacks) was positive enough that it has encouraged them to use the triple-bag technology.

Table 8: Logit Estimates of the Effects of Radio Messages on the Adoption of Triple-Bag Technology for Burkina Faso without Control Villages.

| **Variables** | **Model 1** | **Model 2** | **Model 3** |
|---|---|---|---|
| VILR | 1.091*** | 1.108*** | 1.123*** |
| | (0.253) | (0.252) | (0.252) |
| PP | 2.958*** | 2.944*** | 2.950*** |
| | (0.190) | (0.189) | (0.189) |
| SEX | 0.168 | 0.156 | 0.188 |
| | (0.166) | (0.165) | (0.165) |
| AGE | -0.001 | -0.001 | 0.002 |
| | (0.007) | (0.007) | (0.007) |
| MOSSI | 1.159*** | 1.137*** | 1.216*** |
| | (0.235) | (0.233) | (0.235) |
| SAMO | 0.873** | 0.861** | 0.840** |
| | (0.394) | (0.394) | (0.395) |
| WORKM | -0.057 | -0.061 | -0.064 |
| | (0.064) | (0.064) | (0.064) |
| HHSIZE | 0.027 | 0.025 | 0.033 |
| | (0.023) | (0.023) | (0.023) |
| CONTEXT | 1.306*** | 1.320*** | 1.313*** |
| | (0.200) | (0.200) | (0.200) |
| ASSOC | -0.222 | -0.239 | -0.234 |
| | (0.192) | (0.191) | (0.192) |
| ACTIVITY | -0.705*** | -0.717*** | -0.755*** |
| | (0.281) | (0.281) | (0.280) |
| STORHARV | 0.0003* | 0.0003* | |
| | (0.0002) | (0.0002) | |
| SOLDHARV | -0.0009 | | -0.001 |
| | (0.0009) | | (0.0009) |
| DBLETRPL | 0.571* | 0.601** | 0.504* |
| | (0.303) | (0.301) | (0.300) |
| DRUM | 0.206 | 0.206 | 0.229 |
| | (0.270) | (0.270) | (0.269) |
| TRADTECH | 0.355* | 0.346* | 0.314 |
| | (0.236) | (0.236) | (0.235) |
| INSECT | 0.420* | 0.409* | 0.438* |
| | (0.234) | (0.234) | (0.234) |
| CONSTANT | -4.778*** | -4.758*** | -4.764*** |
| | (0.565) | (0.564) | (0.564) |
| Likelihood ratio statistic | 659.13*** | 675.91*** | 655.58*** |
| Pseudo $R^2$ | 0.383 | 0.382 | 0.380 |

[a] Values in parenthesis below the coefficients represent Standard Errors

* Indicates statistically significant at 90 percent level

** Indicates statistically significant at 95 percent level

*** Indicates statistically significant at 99 percent level

**Results of Marginal Effects**

The estimated parameters of logit models are more easily interpreted in the concept of marginal probability. Given the similarity of the results for the analyses: a) evaluating the effect of the PICS extension program and b) the effectiveness of radio messages; we report the marginal effects for only the former analyses. Results of the marginal effects for model 1 for both Niger and Burkina Faso from Tables 5 and 7 respectively, are presented below in Table 9. A marginal effect is defined as the change in the probability of adopting the triple-bag technology that results from a change of the independent variables, holding all other variables at some fixed values[4].

In Niger, the result for the continuous variable, AGE indicates that on average for a one-year increase in a farmer's age, the probability of adopting the triple-bag decreases by 0.004. The results for the variable STORHARV show that, on average, a unit-increase in quantity of cowpea stored at harvest leads to a 0.001 and 0.0001 increase in the probability of a respondent adopting the triple-bag technology, holding all other variables constant, respectively for Niger and Burkina Faso. We observe that the probability is about 10 times higher in Niger than in Burkina Faso.

Marginal effects of 0.203 and 0.375 for the dummy variable, VIL_DEMO for Burkina Faso and Niger, respectively, suggest that respondents from villages where the PICS extension program was used are 20.3% and 37.5% more likely to adopt the triple-bag technology relative to those from the control villages, holding all else constant. This suggests that the extension program is an effective tool in disseminating information that affects the adoption of technology.

[4] These are set as the modal values for discrete variables and sample averages for the continuous variables.

In both countries, we observe that a respondent who participates in the PICS village level demonstrations has a probability of technology adoption of about 0.53, which is significantly higher than that of a respondent who has no-involvement in village demonstrations in both countries. This suggests that participation has an increased advantage of motivating technology adoption than non-participation. This may be attributable to the fact that participating respondents gain first-hand knowledge on the use of the triple-bag technology and are convinced of its effectiveness.

The marginal effect for the variable, CONTEXT, shows that a farmer, who has had contact with an extension service, is 23% more likely to adopt the triple-bag as a storage technology than a farmer with no contact with extension services in Burkina Faso. For Niger the probability is lower (14.5%). Furthermore, in Burkina Faso, the marginal effect for a respondent who engages solely in farming as their income-generating activity represented by the variable, ACTIVITY, is -0.191. This implies that this category of farmers is 19.1% less likely to adopt the triple-bag technology in comparison to respondents that have multiple sources of income. One explanation of this is that farmers with more resources store more cowpeas and do not need to sell their produce at harvest for cash, thus, have an increased need for better storage technologies. Additionally, these farmers are willing to invest in cowpea production and can actually afford to purchase new storage technologies.

Table 9: Marginal Effects of Model 1 for Niger and Burkina Faso from Tables 5 and 7.

| | **Niger** | **Burkina Faso** |
|---|---|---|
| **Variables** | **Marginal Effects** | **Marginal Effects** |
| VIL_DEMO | 0.375*** | 0.203*** |
| PP | 0.525*** | 0.528*** |
| SEX | -0.654*** | 0.025 |
| AGE | -0.004*** | -0.0001 |
| MOSSI | | 0.149*** |
| SAMO | | -0.055 |
| KANURI | -0.047 | |
| HAUSSA | -0.051 | |
| WORKM | 0.021 | -0.008 |
| HHSIZE | 0.009** | 0.004 |
| CONTEXT | 0.145*** | 0.230*** |
| ASSOC | 0.076 | -0.032 |
| ACTIVITY | 0.001 | -0.191*** |
| STORHARV | 0.001*** | 0.0001** |
| SOLDHARV | 0.000 | -0.0002 |
| DBLETRPL | 0.001 | 0.035 |
| DRUM | -0.025 | 0.103* |
| TRADTECH | -0.005 | 0.089** |
| INSECT | 0.098*** | 0.071* |

* Indicates statistically significant at 90 percent level
** Indicates statistically significant at 95 percent level
*** Indicates statistically significant at 99 percent level

## V. Conclusions

The objective of this paper was to evaluate the effectiveness of alternative extension methods on the adoption of triple-bag storage technology for cowpeas by farmers in Burkina Faso and Niger. The core extension program focused around village level demonstrations of the triple-bag storage technology. One-half of the villages received the core program while the second half of the villages received radio announcements in the local language to augment the core program. Data were collected by way of personal interviews with farmers, selected by a stratified random sample, in both countries. Data included the level of adoption of the triple-bag technology (dependent variable) as well as data on the type of extension programming the village received and farmer and household characteristics as independent variables.

We first examined the question of whether the extension program affected the adoption of the triple-bag storage for cowpeas. The results suggest that the answer is "yes." The coefficients for the variable associated with the village receiving the extension program, VIL_DEMO, were positive and statistically significant for both countries and all models considered. These results provide support for the need to implement an extension program in order to reach farmers and experience the impact of the new innovations or techniques that are often the result of research.

Farmer and household characteristic variables were found to influence the adoption of the triple-bag storage technology for cowpeas, although some results did differ by country. In Niger female farmers were more likely to adopt the triple-bag storage technology and older farmers were less likely to adopt. In contrast, the coefficients for the SEX and AGE variables were not statistically significant in Burkina Faso. There are several possible reasons for the results that women in Niger are more likely to adopt triple-bag storage than men, and worthy of further study. In Niger farmers from larger sized households were more likely to adopt the triple-bag technology, while in Burkina Faso the coefficients were not statistically significant. In Burkina Faso, farmers from the Mossi ethnic group were more likely to adopt compared to those from the Peulh ethnic group. This outcome can be explained by the traditional activities of these groups, since the Peuhl are traditionally nomadic and produce only small amounts of crops and would have limited cowpea to store. Farmers in Burkina Faso who were involved in agriculture plus other activities were more likely to adopt the triple-bag technology than farmers who were involved in agriculture only. One possible explanation is that the non-farm activity provides a source of cash so that farmers can store their cowpeas rather than sell at harvest for needed cash.

In both countries farmers who had used insecticides for their cowpea storage prior to 2007 were more likely to adopt the triple-bag technology. In Burkina Faso there is evidence that prior use of other storage technologies positively influenced adoption, but none of the coefficients were statistically significant in Niger. The fact that farmers who had previously used insecticides were willing to adopt the non-pesticide hermetic storage of triple-bag is very encouraging given the extensive health problems reported in the region as a result of insecticide use (Daily Trust, 2006).

In both countries farmers who reported storing larger quantities of cowpea were more likely to adopt the triple-bag technology, which is logical because these farmers will directly benefit from the improved storage. It is interesting to note that the coefficients for the quantity of cowpea sold at harvest were not statistically significant for any of the models in either country. Two potentially important observations could follow from this. First, farmers that are selling larger quantities at harvest could benefit from storage and receiving a higher price for their cowpea later in the market season. This suggests the importance of emphasizing the gains from cowpea storage due to price increases throughout the market season, as part of the extension programs. Second, farmers may be selling their cowpea at harvest because of the need for cash. This suggests the importance of implementing a credit program for farmers to allow them access to credit for cash that they would use for immediate household needs. The farmers' stored cowpea could then increase in value as market prices rose during the market season.

Second, we examined the impact of using radio messages in local language to augment the core extension program that was focused around village level demonstrations. The results suggest that the use of radio messages does positively affect adoption of the triple-bag technology.

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