

Full Length Research Paper

## Cowpea storage practices and factors that influence choice in Ghana

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Cowpea grain is attacked by the storage weevil *Callosobruchus maculatus* (Coleoptera: Cuculionidae) and can cause 100% grain loss in poor storage. A survey of cowpea storage practices was conducted in 2011 in the major cowpea growing areas of Ghana, viz. Northern, Upper East, Upper West and the northern fringes of the Brong Ahafo Regions. The objective was to identify practices and technologies used by farmers to store cowpea as well as document the factors that influence practices such choices. A total of 320 cowpea producing households from 32 communities were surveyed using semi-structured questionnaires. Data also were collected through desk studies. Results showed that storing with ash and storing in single bags (traditional technologies), and storing in double bags, triple bags, drums and with insecticides (improved technologies) were the cowpea storage technologies used by farmers. Cowpea storage with insecticides was reported by 47% of the respondents and was the most popularly known technology among farmers, followed by the ash technology (24%), single bag technology (20%), double and triple bagging (7%) and the drum technology (2%). The double and triple bag technologies were more popular among farmers in the Northern and Upper West Regions. The ash technology was popular in the Upper East while farmers in the Brong Ahafo Region stored cowpea mainly with insecticides. Sole cowpea cropping was significantly dominant among farmers who have adopted improved cowpea storage technologies (88%) compared with those using traditional storage technologies (77%). Also, membership of a farmer based organization positively influenced farmers adoption of improved storage technologies. These findings have implications for the dissemination of improved cowpea technologies in Ghana.

**Key words:** Cowpea, weevil, *Callosobruchus maculatus*, practices, PICS.

### INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) 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

other export crops such as cocoa (Baributsa et al., 2010). It is also a major staple food crop for people in rural and urban areas. The grain is rich in protein with a protein content of 23.4% when dry and 3.4% when green or fresh (Nimoh and Asuming-Brempong, 2012). Cowpea has been identified as the cheapest source of protein and often referred to as the poor man's meat because of its high protein content (Mishili et al., 2007). Additionally, cowpea is early maturing and often serves as the main

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Figure 1. Administrative map of Ghana.

source of food during the hunger period of July to September in Ghana when most crops are not ready for harvest.

Despite the importance of cowpea, its storage is one of the biggest challenges to small scale cowpea growers and traders. Cowpea storage is limited by insect pests and diseases leading to deterioration. The primary insect causing losses to stored cowpea is the weevil, *Callosobruchus maculatus* (Coleoptera: Cuculionidae). It feeds on the grain and can cause 100% grain loss in poorly stored cowpea (Murdock et al., 2003). According to Baributsa et al. (2010), many farmers prefer to sell their cowpea at low harvest time prices rather than risk losses by weevils during storage. Fungal diseases growing on or in stored cowpea also cause a variety of losses, which include poor germination, discoloration; mustiness and change in taste (Ramirez, 2011).

Farmers use a variety of commercial and traditional methods to control storage pests, many of which have restricted value because of cost, labour and potential toxicity. For instance, insecticides can be used to control cowpea weevils, but majority of farmers and traders lack the needed capital to purchase insecticides and when they do, they often misuse them resulting in health and environmental problems (Baributsa et al., 2010). The need for an effective and efficient storage practice, which is also environmentally and farmer friendly brought to the fore the Purdue Improved Cowpea Storage (PICS) technology. The PICS technology involves storage of grain in a triple bag consisting of an exterior woven bag with two inner airtight hermetic bags. The airtight

condition created by the two inner hermetic bags suppresses the growth and development of the storage weevils. The method is thus very cost effective with 100% grain recovery from storage and also very safe as no chemicals are involved. As part of the dissemination of the PICS technology in Ghana, this study was conducted to assess the level of adoption of cowpea storage technologies as well as document the factors that may be influencing such choices. The results can inform the dissemination process and form a basis for evaluating the success of the PICS project in Ghana.

## METHODOLOGY

### Study area

According to the Ministry of Food and Agriculture, MoFA, (2011), Rain Forest, Deciduous Forest, Transitional Zone, Coastal Savannah and Northern Savannah are the five main agro-ecological zones considering climate and soil type in Ghana. This study was undertaken in the Forest Savannah Transition (Brong-Ahafo Region) and Northern Savannah zones (Northern, Upper East and Upper West Regions) (Figure 1) which have mean annual rainfall of 1300 and 1100 mm, respectively. Cowpea is a major and widely cultivated crop in the area (MoFA, 2011). The transitional zone has a bimodal rainfall pattern and located in the middle belt while the northern savannah has a uni-modal rainfall pattern and located in the north of Ghana. Rainfed agriculture and related trade

is the main occupation of the people in the area.

## Data collection

Both primary and secondary data were collected for the study using a semi-structured questionnaire. Two levels of surveys were conducted for the collection of the primary data. These included community and household surveys. Secondary data were collected mainly through desk studies.

A multi-stage sampling procedure was followed for the selection of the cowpea producing communities and households. Sampling was done in consultation with the regional directorates of the Ministry of Food and Agriculture (MoFA) in the Brong-Ahafo, Northern, Upper East and the Upper West Regions.

At each stage of the sampling process, a list of cowpea producing entities was generated to form the sampling frame. For instance, within each region two districts out of a list of cowpea producing districts were randomly selected. Again, within each of the selected districts, a list of cowpea producing communities was generated and then a sample of four was randomly selected. Within each of the selected communities, a list of cowpea producing households was generated and then 10 were selected for the household interviews. At the village level, a group of key informants between 5 and 10 were engaged in focus group discussions. In all, a total of 320 cowpea producing households from 32 communities were engaged in the study.

## Analytical framework

Multinomial logit or probit is the analytical tool that is often employed in assessing the effects of exogenous variables on an unordered multi choice endogenous variables.

Although both multinomial logit and probit provide similar parameter estimates, it is computationally easier to estimate the former as compared to the latter. Therefore, in modeling the factors that influence farmers' choice of a cowpea storage technology, the study relied on the multinomial logit.

Let  $Y_i$  be a random variable denoting the cowpea storage technology used by a farmer. Assuming that the choice of a cowpea storage technology was made from a basket of mutually exclusive cowpea storage technologies, then a set of explanatory variables including socioeconomic and technical characteristics,

$X_i$  can be used to explain the choice of the cowpea storage technology. The relationship between  $Y_i$  and  $X_i$  can be specified as;

$$\Pr ob (Y_i = j) = \frac{e^{\beta_j X_i}}{\sum_{k=0} e^{\beta_k X_i}}, j = 0, 1, \dots, 10 \quad (1)$$

Where  $\beta_j$  is a vector coefficient. Equation (1) is indeterminate and can only be estimated if and only if the equation is normalized by assuming that  $\beta_0 = 0$  such that the corresponding probabilities will be;

$$\Pr ob (Y_i = j | X_i) = \frac{e^{\beta_j X_i}}{1 + \sum_{k=1} e^{\beta_k X_i}}, j = 0, 2, \dots, 10 \quad (2)$$

Estimating Equation (2) in terms of odds ratio yields;

$$\ln \left[ \frac{P_{ij}}{P_{ik}} \right] = X_i' (\beta_j - \beta_k) = X_i' \beta_j \quad (3)$$

According to Greene (2003), parameter estimates of the multinomial logit are difficult to interpret hence associating the  $\beta_j$ s with the  $j^{\text{th}}$  outcome can be misleading and is inappropriate. The study therefore estimated the marginal effects based on robust standard errors, which is more appropriate and is given by;

$$\delta_j = \frac{\delta P_j}{\delta X_i} = \frac{r_j (\beta_j - \sum_{k=0} r_k \beta_k)}{r_j (\beta_j - \beta')} \quad (4)$$

Greene (2003) posited that the signs of the marginal effects may be different from that of the coefficients since the signs of the marginal effects depend on the sign and marginal effects of all other coefficients. Empirically, the model is specified as;

$$\ln \left[ \frac{P_{ij}}{P_{ik}} \right] = \beta_0 + \beta_1 \text{Sex} + \beta_2 \text{Mar}_{-}\text{stat} + \beta_3 \text{Sol}_{-}\text{crop} + \beta_4 \text{Exper} + \beta_5 \text{HH}_{-}\text{size} + \beta_6 \text{Radio} + \beta_7 + \beta_8 \text{Mem}_{-}\text{FBO} + \beta_9 \text{Exten} + \beta_{10} \text{Ecology} \quad (5)$$

Where  $Y_i$  is the set of storage technologies and practices used by cowpea farmers to store their produce. Description of the exogenous variables with apriori expectations are presented in Table 1.

In order to allow for statistical comparison of the socio-demographic characteristics of respondents, the observations were grouped into two according to the type of storage method, as traditional or improved. Farmers who used triple bags, double bags and drums to store their cowpea as well those who applied insecticides were all classed in the 'improved' group. Ash, sun drying and single bags were considered as traditional methods of

**Table 1.** Apriori expectations of the exogenous variables used in multinomial logit model.

Exogenous variable	Description	Measurement	Apriori expectation
Sex	Sex	Dummy 1=Male, 0=Otherwise	+/-
Mar_stat	Marital status	Dummy 1=Married, 0=Otherwise	+
Sol_crop	Sole cropping	Dummy 1=Yes, 0=Otherwise	+
Exper	Experience in farming	Years	+/-
HH_size	Household size	Number	+/-
Radio	Ownership of radio	Dummy 1=Yes, 0=Otherwise	+
Educ	Received formal education	Dummy 1=Yes, 0=Otherwise	+
Mem_FBO	Membership of a FBO	Dummy 1=Yes, 0=Otherwise	+
Exten	Received extension	Dummy 1=Yes, 0=Otherwise	+
Ecology	Agro ecology	Dummy 1=Interior savannah, 0=Otherwise	+/-

**Table 2.** Socio-demographic characteristics of respondents.

Characteristic	Improved methods	Traditional methods
Male (Percent)	84.3***	88.3***
Married (Percent)	90.8***	89.3***
Sole cropping (Percent)	87.6***	76.7***
Own radio (Percent)	79.7	79.6
Education (Percent)	36.4***	30.1***
Association (Percent)	41.9	52.4
Extension (Percent)	68.2***	64.1***
Savannah (Percent)	67.7***	90.3***
Farming experience (Average)	1.7	1.8
Household size (Average)	9.5***	11.3***

\*\*\*signify statistical significance at 1% level.

storing cowpea. In order to test for statistical difference between the two groups, categorical variables were subjected to the binomial test while continuous variables were subjected to the student t test.

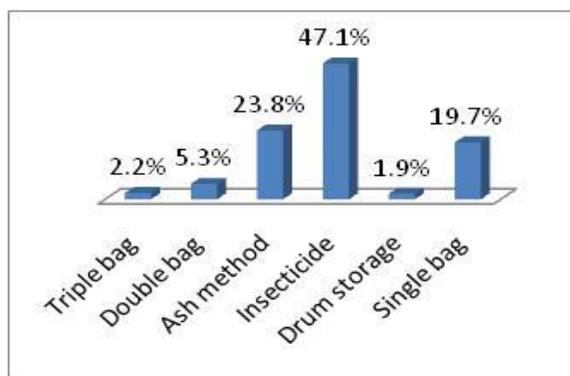
## RESULTS AND DISCUSSION

### Socio-demographic characteristics of respondents

The socio-demographic characteristics of cowpea farmers interviewed are presented in Table 2. Majority of the farmers interviewed were males. The proportion of male farmers who practiced traditional methods of storage was significantly higher than that which stored their produce using improved methods. Males are often the heads of households and bread winners in the study area, and are therefore likely to have more competing demands that may impact their adoption of new technologies. A large proportion of the farmers sampled were married. The percentage of married farmers who adopted improved storage technologies was significantly higher than that which used traditional storage methods.

Married farmers often complement the efforts of their spouses through the entire production and utilisation process. Married couples could therefore combine resources in order to make productive investments in technology acquisition. Also, married farmers are more likely to have need for storage facilities since their combined production is likely to exceed that of unmarried farmers. Exploring for better storage technologies may therefore be more common among married farmers. Furthermore, married farmers may be able to jointly share any risk associated with the adoption of improved cowpea storage technologies unlike unmarried farmers who may have to bear all the risks alone.

Possession of a radio set did not significantly influence adoption of storage technologies in the study area although all radio stations operating in the study area air agricultural programs on a weekly basis. Radio is an important source of entertainment and a source of information as well as a channel for education. A significantly higher percentage of educated cowpea farmers used improved technologies to store their produce compared with those who used traditional methods. Etwire et al. (2013) noted that access to formal



**Figure 2.** Cowpea storage practices and technologies, and percent farmers reporting

education improves farmers ability to comprehend the merits and constraints associated with improved technologies thereby aiding adoption. Educated farmers are usually able to search for information on their own and are often the targets of most agricultural interventions. Also, educated farmers are more likely to have another occupation hence resource constraints may not be a limiting factor to technology adoption. Educated farmers are sometimes recruited and trained as agricultural volunteers, community extension workers, lead farmers and agents of change.

Membership of a Farmer-based Organisation (FBO) did not significantly influence the percentage of farmers who adopted improved cowpea storage technologies. However, access to extension service significantly increased adoption of improved storage technologies. Abebaw and Belay (2001) and Aidoo et al. (2014) reported that access to extension service enhanced the use of technology. The Savanna Agricultural Research Institute of the Council for Scientific and Industrial Research (CSIR-SARI), University for Development Studies, International Institute of Tropical Agriculture and other research institutions are located within the study area and also extend agricultural technologies including improved cowpea storage technologies to farmers. In addition, the study area has a high concentration of both local and international Non Governmental Organization (NGO) that are complementing the efforts of the national agricultural extension system in disseminating improved technologies to farmers.

Cowpea can be grown as a sole crop or as an intercrop. Sole cropping was practiced by a significantly higher proportion of cowpea farmers who adopted improved technologies compared with those using traditional methods to store their harvest. Sole cropping tends to lead to specialization which may result in farmers searching for more knowledge and technologies about the crop. Also, cowpea farmers who practice sole cropping are more likely to be able to concentrate their resources on their farm than those engaged in mixed cropping who will have to share their resources among

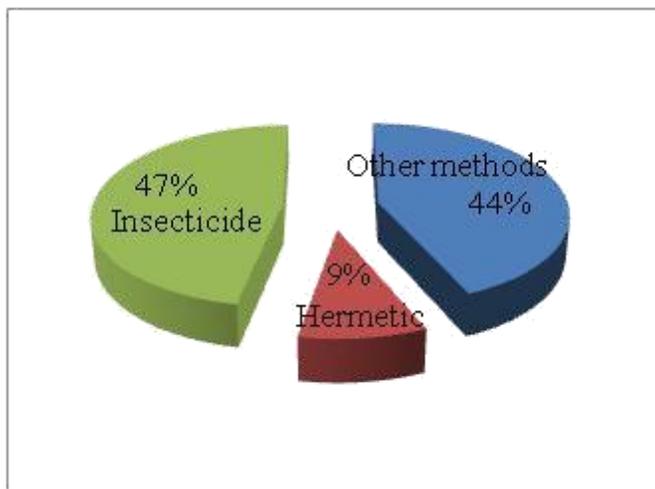
the various crops. Furthermore, farmers generally harvest more from sole crops relative to mixed crops. Thus, farmers who practice sole cropping may require storage facilities and are therefore more likely to adopt storage technologies. Cowpea farmers who practice sole cropping are also likely to suffer more in case of storage loss as compared to farmers who grow several crops. Consequently, sole croppers are more likely to adopt technologies that are capable of minimizing storage losses. The proportion of farmers in the northern savannah zone that used traditional methods to store their cowpea was significantly higher than the proportion of farmers that stored their produce with improved storage technologies. Majority of the farmers in the zone had small farm holdings and probably individually had little harvest to warrant the investment and adoption of improved storage practices. In addition, most of the farmers had no formal education, which could have impacted their adoption of improved storage technologies (Etwire et al., 2013).

On average, the farmers interviewed had two years experience in cowpea production. A farmer who has a lot of experience in cowpea production may likely get exposed to many improved technologies and may be able to identify technologies that work well or are likely to work well. Experience may therefore be important in influencing the choice of a cowpea storage technology. Farmers who used traditional methods to store their cowpea had a significantly higher mean household size compared with those who stored their produce with improved technologies. An increase in household size has direct consequences on household expenditure which limits the resources available to invest in a new storage technology. Also, building consensus in order to make a decision on technology adoption may be difficult as the size of the household increases.

### **Cowpea storage practices and technologies**

Six different techniques were used by farmers to store and preserve harvested cowpea (Figure 2). Cowpea was usually stored at the household or farmer level, with little availability and utilisation of commercial storage facilities at the community or district level.

About 20% of the surveyed reported storing their cowpea in single 50 or 100 kg polythene or jute bags. Some of the farmers said they applied insecticides to the beans before storing in the bags. This type of storage was readily available in most farming communities and also used to store other grains apart from cowpea. Single bags have little practicability in protecting the beans against insect attacks or preserve the quality of the produce. About 47% of the respondents reported using insecticides in storing their cowpea. Chemical insecticides used included phostoxin and actellic, while neem extract was the main non chemical insecticide used. These chemicals were admixed with whole grains



**Figure 3.** Categorization of cowpea storage practices and technologies.

before storage. Most of the farmers perceived insecticides to be very effective in minimizing insect attacks and preserving storage. However, abuse of these chemicals does have negative consequences on human health (Abudulai et al., 2006). About 24% of the farmers interviewed applied wood ash to their cowpea before storage. It was usually added on top of the grains as a traditional insecticide before storage. Baributsa et al. (2010) posited that many people consider ash as dirty and therefore refuse to eat food stored in ash. About 2% of the respondents reported using triple bags to store their cowpea. Triple layer hermetic bags have been found to reduce damage and weight loss as well as maintain taste and seed vigour (Anankware et al., 2012, 2013). In Ghana, triple bags have been promoted heavily by Purdue University as PICS bags. When one layer of the bags of a triple bag is destroyed or removed, it reduces to a double bag. Double bags have similar qualities to triple bags except that they are made up of only two components, an outer and inner layer. About 5% of farmers interviewed used double bags to store their cowpea. Before the introduction of the triple bag technology, farmers on their own had devised ways of storing cowpea under airtight conditions. This was achieved by storing cowpea in drums. About 2% of the respondent farmers stored their cowpea in drums.

### Factors influencing the choice of cowpea storage technology

In order to estimate the factors that determine the choice of a particular storage method, the six storage technologies identified with farmers were categorized into three as shown in Figure 3. The triple and double bag technologies as well as the drum method were jointly classified as hermetic storage method since all these methods were based on the airtight principle. About 9%

of the respondents used the hermetic technology for cowpea storage. Farmers that used insecticides were maintained as a separate category and consisted of 47% of the respondents. All other farmers specifically, those who used the ash method, sun drying and single bags were categorized as 'other methods'. The 'other methods' were more or less the traditional methods of storing cowpea in the study area. This category (base outcome) formed about 44% of the respondents.

The marginal estimate of the multinomial logit model which formed the basis for discussion of this paper is presented in Table 3. The results indicated that being a member of a FBO and cultivating cowpea as a sole crop were the factors that influenced the adoption of hermetic technologies for cowpea storage in the northern savannah and forest transition zones of Ghana.

The probability of adoption of hermetic storage increased by about seven percent if a farmer belonged to a FBO. Group and mass methods of communication appeared to be the most preferred medium of communication of agricultural extension messages relative to individual and personal means of communication that had a limited scope because of scarce resources. A farmer who belonged to a FBO was more likely to have access to information on a new agricultural technology compared to a farmer who worked alone. Moreover, leaders of FBOs often seek information on technologies that can address production and post-harvest constraints including storage. In addition, some FBOs take advantage of economies of scale to procure goods and services such as hermetic storage materials, fertilizer and herbicide in bulk for their members. Also, a FBO provides an avenue for networking. Any member who has tried or is exposed to a new technology may introduce other members of the group to the technology especially if the technology proved to be effective. Further, FBOs are increasingly becoming the main targets of agricultural development interventions in most parts of Ghana. Most development and agricultural extension workers prefer to work with FBOs relative to individuals or loose groups. Adoption of a technology by several members of a FBO tends to have a reassuring effect on individual members since risk of technology failure is borne by several members.

The findings of this study met apriori expectations. They corroborate the findings of Awotide et al. (2012, 2013) who observed that being a member of a farmer association significantly influenced the intensity of adoption of improved rice varieties in rural Nigeria. Similarly, Kijima and Sserunkuuma (2013) reported that in the early stages of NERICA diffusion in Uganda, being a member of a farmer group increased the probability of adoption. In Ghana, Wiredu et al. (2011) and Ibrahim et al. (2012) found a positive and significant relationship between being a member of a FBO and adoption of hybrid cocoa and improved groundnut varieties respectively. Moussa et al. (2009) however did not observe any significant relationship between membership of a FBO and adoption of the PICS technology in Niger and Burkina Faso.

A sole cowpea farmer had a 17% probability to adopt a hermetic storage technology as opposed to using other

**Table 3.** Marginal effects of factors that influence the choice of cowpea storage technologies.

Variable	Hermetic	Insecticide
Sex	0.0622	-0.0938
Marital status	-0.0134	0.1171
Sole cropping	0.1673*	0.0004
Experience	-0.0014	-0.0376
Household size	-0.0009	-0.0082
Radio	-0.0048	0.0434
Received formal education	-0.0441	0.0703
Membership of a FBO	0.0714*	-0.0777
Received extension	0.0418	0.0151
Agro ecology	-0.0589	-0.2076***
Base outcome		Other methods
Number of observations		320
Wald chi2 (20)		44.86
Prov > chi2		0.0012
Pseudo R2		0.0803
Log pseudo likelihood		-269.4695

\*, \*\*\*represents statistical significance at 10 and 1% levels respectively.

methods of storage. Farmers who practice sole cowpea production tend to specialize in its production and are therefore more likely to enquire about new cowpea production and storage technologies. A cowpea farmer is likely to harvest more from a hectare of sole farm than from a mixed farm *ceteris paribus*. The high level of production may necessitate storage. Thus, farmers who practice sole cropping may need to store some of their produce and could possibly adopt the hermetic storage technology. Moreover, farmers who practice sole cropping, unlike mixed cropping, may concentrate their resources on the sole crop and may be in a better position to invest in hermetic cowpea storage technologies.

Use of insecticides for cowpea storage was influenced positively by a farmers' location in the forest transition agro-ecology. The probability of treating cowpea with insecticides before storage relative to using traditional methods increased by about 21% if a farmer was located in the forest transition zone of Ghana. The northern savannah zones of Ghana account for about 90% of national cropped cowpea area and about 95% of national cowpea production (SRID, 2012). Farmers in the agro-ecology are therefore more likely to store large quantities of cowpea as compared to farmers in the forest transition zone. However, most farmers in the zone are poor (Ghana Statistical Service, 2008) so few are able to afford insecticides. Rather, majority of them use traditional storage methods. Several authors have found a relationship between adoption of improved technologies and agro-ecology or location. Etwire et al. (2013) reported that a farmer in the Guinea savannah agro ecology was more likely to adopt an improved soil

technology to mitigate the negative effects of climate change compared to a farmer in the Sudan savannah agro ecology. Agro ecology was also found to have a positive and significant influence in the adoption of fertilizer, crop variety and livestock breeds in rural Ethiopia (Goshu et al., 2013). Kisaka-Lwayo (2007) reported that the location of a farmer had an influence on the adoption of certified organic farming in South Africa. The location of a farmer was also found to have an influence on the adoption of improved groundnut varieties in Malawi (Simtowe et al., 2010).

## CONCLUSIONS AND RECOMMENDATIONS

Cowpea production in Ghana appeared to be male dominated. Sole cropping was the main cropping system with production mainly in the hands of married farmers. Cowpea producers used a variety of technologies and practices to store their produce. Conventionally, cowpea was stored in single bags after sun-drying or treatment with ash. Application of insecticides to the grain before storage was also common. Hermetic storage technologies such as triple bags, double bags as well as drums also were used to store cowpea. Idiosyncratic characteristics such as household size, agro-ecology, access to formal education and agricultural extension service were important in influencing farmers' choice of storage technologies. Producing cowpea as a sole crop and being a member of a FBO were the factors that positively influenced the choice of hermetic storage. Agro-ecology significantly influenced the use of insecticides for storage, with insecticide treatment before

storage being more common in the forest transition than in the northern savannah zone. The findings of this study have implications for policy.

The Ministry of Food and Agriculture together with other agro-based state institutions and NGOs should encourage more women to produce cowpea. Due to its potential in balancing household nutrition, there is the need to promote the crop especially in the cereal-based farming system of northern Ghana. In order to minimize storage losses and the harmful effects of storage chemicals, there is an urgent need to widely promote hermetic storage technologies for cowpea. The northern savannah zone of Ghana, where cowpea is dominant, should be targeted for maximum impact. Agricultural extension staff as well as development workers should be continuously supported to continue to animate and facilitate the formation and strengthening of FBOs. Finally, heavy use of insecticides for cowpea storage should be discouraged especially among farmers in the forest transition zone. There is the need for research and extension institutions to intensify the promotion of integrated pest management technologies for cowpea storage.

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