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Assessing drivers of maize storage losses in south west Benin using a Fractional Response Model

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Abstract

An assessment of drivers of maize storage losses was undertaken in south west Benin applying the Fractional Response Model on information collected from 400 smallholder maize farmers. Overall, respondents lose on average 10.3% of their harvest during the storage period. The average marginal effect obtained from the fractional response model of storage losses revealed that storage technologies, farmers' post-harvest attitudes, insects damage, the weather conditions and infrastructures played a significant role in the level of storage losses surveyed farmers have experienced. Farmers using bags and plastic containers have respectively reduced their storage losses by 6.7 and 7.8% compared to farmers using cribs. Considering the use of storage protectant, the results indicated that using ash, neem leaves, pepper or lemon lead to an increase of 4.1% of losses relative to storing without any protectant. Drying after harvesting decreased by 1.9% the share of the quantity stored lost during storage. The percentage of maize lost increased by 5.1% for respondents who have reported insects as predators of their stored maize. Rain at harvest time increased the percentage of losses by 2.1%. A one-degree increase in temperature increased the percentage of maize loss by 4.4% and farmers who live at less than 26.5 km to the market have reduced by 0.17% of maize losses. Effective policies for a sustainable reduction of storage losses among maize farmers in the area should consider the need to discourage the use of cribs, ash, leaves, pepper and lemon as storage technologies. Farmers should avoid harvesting during times of rain, and should properly dry their produce after harvesting. Sustainable hermetic equipment should be promoted and farmers' access to markets facilitated.

Keywords: Maize; Storage equipment; Storage protectant; Storage losses; Fractional Response Model

1. Introduction

Each year, significant volumes of food are lost after harvest in Sub-Saharan Africa (SSA), the value of which is estimated at USD 4 billion for grains alone (World Bank, 2011). World Bank (2011) emphasizes that the high level of grain lost in developing countries after harvest, in addition to aggravating hunger, also leads to a waste of expensive inputs such as irrigation water, fertilizer and human labour. Storage is a critical stage in the food supply chain. In developing countries with hot climates, most smallholder farmers rely on sun drying to ensure that crops are well dried before storage. If unfavourable weather conditions prevent crops from drying sufficiently, such crops are subject to high losses during storage (Hodges *et al*., 2014). The need to deal with post-harvest losses and to undertake innovative and impact oriented PHL research is critical for achieving food security and reducing poverty in the sub region (Affognon *et al.,* 2015).

A major obstacle in the efforts to mitigate storage losses in developing countries is the lack of accurate knowledge on the magnitude of losses as well as the linkage between drivers of such losses. Outdated contextual estimates of these losses could lead to the implementation of bad policies (Affognon *et al*., 2015).

This paper offers a good understanding of the scope and nature of the problem of storage losses among maize farmers in south western Benin where maize is considered as an important food crop; mainly produced under rain fed agriculture by smallholder farmers and subject to important storage losses. The study is the first in Benin to assess drivers of storage losses in a multivariate setting. Planners and policy makers can rely on the results of the study to as early as possible in their decision cycle design appropriate and effective measures for storage loss reduction.

2. Materials and Methods

Data were randomly collected from over 400 farmers from September to October, 2016. Secondary information on temperature and rainfall pattern during 2015 were obtained from the local climate agency, known as ASECNA Benin/ Lokossa Station.

The dependent variable of interest in this study is the percentage of maize storage losses in south west Benin. The Fractional Response Model (FRM) has been defined for the first time by Papke and Wooldridge (1996) to deal with situations where the dependent variable is a proportion and its values are allowed to be zero or one. Authors have shown that the use of the Ordinary Least Squares (OLS), the censored regression (Tobit), or the transformed logistic normal model (the log-odds ratio of the dependent variable) in such cases are inefficient, as their error distributions will be heteroskedastic (Papke and Wooldridge, 1996; Kieschnick and McCullough, 2003). The Fractional Response Model is a non-linear model estimated using the Quasi-Maximum Likelihood Estimation (QMLE) method. The QMLE is asymptotically efficient and consistent compared to either OLS or Tobit. In the FRM model, a functional form for the dependent variable is chosen such that it imposes constraints on the response variable to ensure that predicted values will always lie within the closed interval [0,1].

The empirical FRM specification of storage losses retained in this study is:

$$E(Y_i/X_i) = G(X_i) = \mathrm{b}_0 + \sum_{k=1}^{24} b_k X_{ik} + \varepsilon_i \quad E(Y_i/X_i) = G(X_i\beta) = b_0 + \sum_{k=1}^{n} b_k X_{ik} + \varepsilon_i \qquad (2.1)$$

Where $0 \leq Y \leq 1$ correspond to the percentage of storage losses; X_i represent the explanatory variables for each observation *i* and ε$^{\varepsilon}$ represents the error term. *G(.)* is a distribution function similar to the logistic function.

Following Papke and Wooldridge (1996) and Wooldridge (2011), the generalised linear modelling (glm) was retained to fit the fractional response model for the percentage of storage losses in south west Benin.

3. Results

The volume of reported storage losses by maize farmers from the south western of Benin is on average 10.3% of the quantity harvested.

Storage equipment

The marginal effect computed from the fitted model showed that farmers using bags and plastic containers respectively have reduced their storage losses by 6.7 and 7.8% compared to farmers using cribs. There is however no difference between the predicted storage losses of users of rooms and cribs.

Storage protectant

Considering the use of storage protectants, the results indicated that using ash, neem leave, pepper or lemon leads to an increase of 4.1% of losses relative to storing without any protectant.

Drying

The results revealed that drying after harvesting decreased by 1.9% the share of the quantity lost during the storage period. Drying the harvest for a second time at home lowered the moisture content of maize and this significantly contributes to a loss reduction.

Insect attacks

The amount of maize lost during storage has increased by 5.1% for respondents who have reported insects as predators of their produce kept in stores.

Rains at harvest

The effect of rain at harvest time was significant and increased the percentage of losses by 2.1%. This result was expected, since rain at harvest time raises the issue of moisture content in harvested crops. The higher the wetness/moisture/dampness of the grain before storage, the higher is the likelihood of losing maize while being kept in stores.

Temperature

The temperature within the first three months of storage had a significant effect on the percentage of maize loss during the storage period. A one-degree increase in temperature increased the percentage of maize loss by 4.4%. The significant effect of temperature on losses is in line with the literature, where the climate conditions have been suggested as a factor in storage losses by Costa (2014). However, the study revealed a turning point of 26.8 over which the temperature contributes to losses reduction.

Market conditions

Market conditions have been tested through price and the distance to market. Prices do not significantly affect the percentage losses. However, the distance to market revealed a non-linear effect on the percentage losses. A one kilometre increase in the distance to market reduced by 0.2% of maize loss and this is true only when the distance to market is less than 26.5 km, the computed extremum. Beyond that, it contributes to storage losses. This result shows that distance to market remains an important issue when it comes to commercializing agricultural products.

4. Discussion

Cribs that are widely used are subject to storage losses. It suggests that awareness should be raised about the storage losses issue, as this is strongly related to the use of cribs in the region. The results show some limit within farmers' attitudes when it comes to preserving their maize product using storage protectant. The study revealed the irrelevance of using ash, neem leaves, pepper and lemon to store maize in south west Benin. The inefficiencies may be explained - without a proper investigation on the issue - by the fact that ash, pepper, lemon and neem leaves are commonly poured on the maize (especially in layers for neem leaves) with husk kept in stores. The fact that insects are damaging the grain itself and are even living inside the maize, the presence of husk between the used protectant and the stored product could prevent the effectiveness of the given protectant.

In the region, maize drying is commonly done in the field before harvest. However, some farmers reported drying their produce a second time before storage. This has contributed to storage losses reduction. Accordingly, dryer technologies with low fixed and operationalisation cost could be implemented in the region. This may help farmers reducing their losses by firstly harvesting after maturity of the crops and then drying adequately. Solar maize dryers could therefore be a better alternative.

Insect attacks remain a challenge for maize farmers. Insect infestation starts from the field when crops are not well treated and / or during the storage period. The effect of insects in damaging or destroying the edible part of the grain put in storage is well documented in the post-harvest literature (Hodges *et al.,* 2014), and that issue is not new. Unfortunately, insects continue to be a threat to maize farmers whose products are kept in stores. Recently, modern hermetic storage equipment have been suggested as a sustainable way to overcome the insect problem (Costa, 2014). Finally, farmers have to avoid harvesting during times of rain and their access to markets should be facilitated to effectively reduce losses that are likely to occur during storage.

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Insects and fungi in stored maize in Angola

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Abstract

In underdeveloped countries in Asia and Africa, non-effective post-harvest technologies and sometimes ideal environmental conditions for development of pests like insects, fungi, rodents and birds, can lead to damage of both raw or processed foods. Losses can achieve considerable proportions in dried vegetables used as food products, particularly in underdeveloped countries where food security problems are a daily basis routine. The major goal of the present study was the identification of insects and fungi associated with maize under local storage conditions in the Angola provinces of de Benguela, Bié, Cuando Cubango, Cuanza sul, Huambo, Huíla, Luanda, Malange and Namibe. A wide range of storage methods for cereals were sampled, from small containers of peasants and small farmers up to the large metal containers used by large agricultural companies and Estates. The achieved results will contribute for food security improvement in Angola and for the maintenance and preservation of good and healthy seeds at the traditional farmers' community level. The insect pests registered from the studied samples were *Cryptolestes ferrugineus, Gnatocerus maxillosus, Liposcelis bostrychophila, Oryzaephilus surinamensis, Rhyzopertha dominica, Sitophilus zeamais, Sitotroga cerealella and Tribolium castaneum*. The species *Prostephanus truncatus* was not found in the studied samples. Fungi in the genus *Aspergillus*, *Fusarium* and *Penicillium* were presented at a high incidence in all samples studied, although the relative abundance of different fungi species varied with the sample location.

Keywords: maize, insects, fungi, Angola, storage.

Introduction

In Angola, maize is the cereal with the highest production and one of the most consumed. An average maize yield of 640 kg/ha was reported for the period 2000-2010 (FAOSTAT, 2012). Although grain production in the country has increased, Angola still has a deficit of 3 million tons, achieving only 40% of consumption needs (INCER, 2014). Factors such as severe technical knowledge gaps, lack of incentives to producers, low fertility of soils, use of low-yielding varieties, non-application of technologies or lack of access to them, lack of access to production factors, lack of infrastructure for water management, lack of reliable storage structures, and low availability of credit resources greatly reduce the expected yields (Pacheco et al., 2011). There are a number of warehouse systems and warehouse types in Angola at the smallholder level. These warehouses are built with clay, sticks and covered with grasses or wood and grass. The poor condition of the warehouse structure, its hygiene and moisture control issues at the level of the small producer does not guarantee good phytosanitary status for the stored products.

Cereals storage is a specific agro-ecosystem, conditioned by several factors which are difficult to control, like temperature, relative humidity, water content, and oxygen availability (Barros, 1993). This is especially true in underdeveloped countries where technological innovations such as refrigeration and controlled atmospheres represent huge investments. Storage under deficient conditions can lead to insect or fungi attack, inducing organoleptic changes (taste, flavour and appearance), nutritional losses or even mycotoxin contamination. These cause significant economic losses and can represent serious health problems.