Crop Protection 104 (2018) 92–100

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Economic consequences of post-harvest insect damage in Rwandan common bean markets

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ARTICLE INFO

Keywords:
Post-harvest losses
Crop storage
Storage technology
Common beans
Rwanda
Sub-saharan africa

ABSTRACT

Post-harvest losses have major economic consequences for smallholders in sub-Saharan Africa. One significant contributor to economic losses is price penalties for poor quality marketed grain. This study investigates farm-gate level discounts demanded by rural Rwandan bean traders for insect-damaged common beans. We use a simplified contingent valuation methodology with physical bean samples to elicit seasonal damage discount schedules based on data from 270 trader interviews in 25 regionally-diverse rural markets, in periods of both common bean abundance and scarcity. While levels of 5–10% insect damage can generally be sold with a moderate discount, beans with 20–30% insect damage are largely unmarketable. We model the physical and non-physical drivers of buying insect-damaged beans and, if so, the extent of discounts demanded. Results indicate that while insect damage levels play a central role, large volume traders penalize damage less while traders in the seed market, storing before re-sale, or purchasing heavily from farmers (vs. other traders) penalize damage significantly more. Findings help develop more evidence-based extension programming and methods could be adapted as an easily implemented and potentially insightful model for developing country agencies. Additionally, derived discount coefficients help evaluate the cost-effectiveness of technologies throughout the region which prevent post-harvest damage.

1. Introduction

Post-harvest losses are a major contributing factor to food and income insecurity in sub-Saharan Africa (SSA). Physical grain losses from insects, mold, and rodents are estimated at 10–20% of production (World Bank, 2011) and calls have been made to increase investment in harvesting, processing, storage technologies and training in developing countries to address this key constraint to food security (Lybbert and Sumner, 2012). Storage insects in particular cause significant losses for grain and legume producers (see: Affognon et al. (2015) and references therein). However, while many studies focus only on physical grain losses in storage, farmers and stakeholders are generally most interested in the economic implications of such losses and thus the value of preventing such damage. Economic losses through insect damage result from reduced quantity and quality of food for home consumption and a significant reduction in grain value for market sale. Ndegwa et al. (2016) provide key insight through a randomized control trial with Kenyan maize producers, demonstrating that profitability of storage technologies is tied to the level of abated loss, length of storage, and number of seasons the technology can be reused. However, marketing producers in particular may find that price discounts for insect damage can be a stronger driver than quantity losses in total economic (value) loss in storage (Jones et al., 2014). For producers lacking effective storage technology, damage discounts in the market can also quickly erode gains from seasonal price increases. Due to inadequate protection and serious credit constraints, producers may decide to sell early at low prices, preventing them from capturing profits that could otherwise be obtainable with later sale at typically much higher prices (Stephens and Barrett, 2011).

In light of these concerns, this study seeks to better understand the economic impacts of post-harvest losses by focusing on how insect damage affects smallholder farmers in rural market transactions. We investigate this subject through the lens of common bean (*Phaseolus vulgaris*) markets in the Republic of Rwanda. This demand driven research was carried out through a collaboration with the Rwandan Ministry of Agriculture and Animal Resources (MINAGRI). In 2010, MINAGRI created a Post-Harvest (PH) Task Force to combat post-harvest management challenges arising after their efforts to raise yields through the Crop Intensification Program. The PH Task Force was charged with developing a national post-harvest strategy, with a goal to

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https://doi.org/10.1016/j.cropro.2017.10.015
Received 8 June 2017; Received in revised form 18 October 2017; Accepted 20 October 2017
Available online 15 November 2017
0261-2194/

develop and execute an evidence-based post-harvest extension program. Common beans are a nationally important source of protein and culturally significant food item in Rwanda. Bean producers widely recognize post-harvest constraints and have demanded more marketing information and post-harvest training (Mvumi et al., 2012). Thus, common beans are a natural focus crop for the PH Task Force. Mvumi et al. (2012) conducted a post-harvest bean survey in Rwanda and found that insect damage is the greatest factor in farmers' frequent market rejection for poor quality beans. Therefore, understanding the economic implications of insect damage is important to provide evidence-based information to farmers regarding marketing strategies as well as assessing the value of grain and legume storage technologies.

Responding to this call, the primary objective of this study is to quantify the price discounts which Rwandan farmers face when selling insect-damaged common beans. We also present novel analysis demonstrating that discounts vary with key trader attributes. A second objective is to develop a method for quantifying farm-gate price discounts that MINAGRI and similar institutions can implement in the future as part of ongoing monitoring efforts. In doing so, this study contributes to the growing post-harvest losses and grain storage literature in SSA. Additionally, we attempt to provide a methodological road-map for institutions seeking to assess market implications of grain and legume insect damage as part of a broader post-harvest loss assessment.

The literature on grain and legume damage discounts in SSA examines the issue both at the farm-gate, where traders buy from farmers, and at the retail level, where consumers purchase from traders. While distinct, the two levels are inherently linked as traders should pass all or part of discounts demanded by consumers on to farmers at the point of farm-gate purchase. The farmer may also sell directly to consumers in rural markets; however in surveyed Rwandan markets the volume of these sales was generally low, especially in months after long storage periods.

This article focuses on farm-gate discounts for insect damage because farmer welfare is directly impacted. To our knowledge, we are the first to estimate farm-gate level market discounts for common beans in SSA. Previous research in legumes has focused on the retail-level discounts for Tanzanian common beans (Mishili et al., 2011) and for West and Central African cowpea (Langyintuo et al., 2003, 2004; Faye et al., 2004; Mishili, 2005; Mishili et al., 2009; and Ibro, 2011). The method employed in previous research was hedonic price modeling, where researchers make weekly market purchases and record the physical, chemical, and price characteristics of legume samples. After enough observations are collected over multiple years, regression analysis is conducted to isolate the effects of each characteristic on price, including insect damage. Mishili et al. (2011) find a 2.3% reduction in price for every hole in 100 common bean seeds, but discount variation across seasons is not assessed. Cowpea researchers find a wider range of discounts across West and Central African markets, from a 0.17%–2.30% reduction for every hole in 100 cowpea seeds (Langyintuo et al., 2003, 2004; Faye et al., 2004; Mishili, 2005; Mishili et al., 2009; Ibro, 2011). While researchers hypothesized West and Central African cowpea consumers would tolerate some insect damage before demanding a discount, or the presence of a ‘damage tolerance threshold’, they found consumers discount from the very first insect hole. Overall, the advantage of hedonic pricing methods is that the data are based on revealed preferences, i.e. actual prices of grain traded in the marketplace and detailed laboratory analysis of each sample. The disadvantage of hedonic pricing methods is the financial and time investment required to collect this detailed level of laboratory analysis and multi-year price series.

Another possible methodological approach is experimental auctions. Group second-price sealed auctions (Vickrey, 1961) and individual Becker-DeGroot-Marshack (BDM) simulated auctions (Shogren, 2005) have been applied to elicit Kenyan consumers' willingness-to-pay for maize color, vitamin fortification, aflatoxin certification, and grain source (De Groote et al., 2011; Hoffmann and Gatobu, 2014). A clear advantage of these auction methods is the incentive compatible nature of linking willingness-to-pay estimates to true underlying preferences. However, experimental auctions require substantial time, effort, training, and are quite costly to implement. Specialized training is required for enumerators and several preliminary rounds of on-site “training” is necessary to accustom participants to the method. Most importantly for our research context, Rwanda's MINAGRI has a strict policy against involving money in surveys. Therefore, beyond logistical concerns, it is the ultimate payment for goods - a key advantage of experimental auctions - which renders this approach infeasible in our context.

Farm-gate level research, at the point of sale between the farmer and the trader, is extremely limited. The first work in sub-Saharan Africa was conducted by Compton et al. (1998) for Ghanaian maize, in which visual samples of varying grain damage were appraised by focus groups of grain traders at strategic times during the storage season. Grain samples were ranked according to damage levels by focus groups, arranged linearly in rank order, and then appraised for price in a group setting. Researchers found a 0.60–0.97% price reduction for every 1% damaged maize kernels, with clear differences in seasonal discount intensities. Traders became more tolerant of grain damage later in the season when grain is scarcer and the presence of insect damage is more common; in this lean or “hunger” season they found a threshold of 5–7% grain damage before discounts were applied. The advantages of the method employed by Compton et al. are the ease of visual scale construction and data collection implementation, as well as the focus on the farmer-to-trader point of sale. The disadvantage is that the linear and simultaneous display of grain damage samples does not reflect the way grain samples are presented to market traders in reality and may present an anchoring bias. A farmer's grain is also typically appraised by individual traders, not large groups of traders, and appraisal in panel-group setting may decrease naturally inherent variance in application of grain damage discounts.

Jones et al. (2016) employed a choice model approach with Malawian maize traders using physical maize samples with varying levels of insect damage, mold damage, and local vs. hybrid varieties. The advantages of the choice model approach include the ability to statistically rank the importance of grain quality attributes, and to statistically recognize and control for respondents ignoring certain attributes. The disadvantages of the choice model approach are that it relies on stated preference data and the execution and analysis is complex, requiring specialized training.

The choice of methodology to measure farm-gate insect damage discounts in common beans was designed to meet the needs of the MINARGI PH Task Force. The PH Task Force explicitly requested a methodology without financial transactions that they could easily replicate, considering time and cost constraints, as well as a straightforward statistical approach. Based on the literature, we decided that the most effective and reproducible way to approach Rwandan common bean discounts for insect damage would be:

1) At the farm-gate level (discounts demanded by traders purchasing from farmers)
2) Using physical bean samples
3) Conducted in actual common bean markets on market days
4) With individual bean traders
5) At multiple time periods to contrast discounts in immediate post-harvest months with discounts found after many months of storage
6) An analytically straightforward method to facilitate local institutional replication

2. Materials and methods

2.1. Bean samples and Elicitation procedure

First, we constructed physical samples of beans to display graduated insect damage levels. The same bean samples were used in every market