Abundance and diversity of arthropod pests infesting stored maize in smallholder farmers and traders systems highlight critical points for pest management in Uganda

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Abstract

Knowledge of the diversity of arthropod pests infesting stored maize value chain in Uganda is very scanty to guide the development and implementation of management strategies. From a cross-sectional study conducted in north western, eastern and central regions of Uganda during 2017/2018, the diversity and economic importance of storage arthropod pests of maize in farmer storage, trader/retailer stores in villages and townships, and in milling and processing facilities is presented. A total of 11 insect pests were recorded feeding internally and externally on stored maize. Rhyzopertha dominica, Sitophilus zeamais and Sitophilus oryzae were the primary insect pests followed by Tribolium spp., Cryptolestes spp., Sitotroga cerealella, and Oryzaephilus mercator. The highest insect diversity and damage was recorded when maize was stored with husked cobs in farmers' houses, a practice farmers use to store seed for next planting. Meanwhile the distribution pattern of the pests in trader/retailer stores in villages and townships, and in milling facilities indicate waves of insect infestation occurring with stocks of grain being brought in storage. The maize grain at the peak of harvesting was in excellent quality but later stocks brought in several months after harvest were infested with diverse insects. Re-drying at farm level and use of chemical dusts at trader/retailer stores in villages and townships were the most common pest management practice. However, the lack of a differentiated market, whereby better quality would fetch premium price, discourages investment to reduce postharvest losses. Subsequently, most farmers sold their grains immediately after harvest and most traders sold their stocks as soon as there was the next bulk buyer. The critical point for pest management is at farm level where pest diversity and damage is greatest, and at the village/ township stores where the grain may be held in anticipation of improvement in price.

Introduction

Maize is the important cereal crop grown in most parts of the Uganda for food, feed and income, (Asea. et al, 2014). The maize sub-sector in Uganda is estimated to provide a livelihood for about 3 million farm households, close to 1,000 traders and over 20 exporters (UBOS, 2017; UBOS and MAAIF. 2011). As elsewhere in eastern and southern Africa, maize is increasingly the staple food of choice in many parts of the country, providing over 40% of the calories consumed in both rural and urban areas (Mason and Smale, 2013; Byerlee et al., 1994). Nutritionally, maize whole grain of 100g contain 10g of protein (poor in trytophan and rich in leucine) and 4gm fat, and provitles 360 calories; the germ (12% by weight of the whole grain)) contains 22% of the total protein and 80% of the oil (Nuss and Tanumihardjo, 2010; Shah et al., 2016).

Smallholder farmers dominate maize production in Uganda, generally characterized by small farm acreage (0.5- 5 ha) (MAAIF, 2013), low yields (1.0 -1.8 MT/ha) and high production costs and consequently low returns. Unfortunately, poor post harvest handling and storage practices have led to low grain quality reducing potential income for smallholder farmers by ~$300/ha per annum and limiting market volume potential. The inefficient traditional drying methods, high moisture levels and lack secure storage have led to low quality grain susceptible to fungal diseases and insect pests. It is estimated that 5-15 % of the maize produced each year is lost over a period of 3-6 months during storage as a result of storage pest damage (Affognon et al., 2015). Elsewhere, comprehensive lists of insect fauna infesting maize are available, for example Ethiopia (Tadese 1996; Walker and Boxall 1974.), Malawi (Schulten, 1974), Saudi Arabia (Rostom, 1993). However, very little work has been conducted in Uganda to understand the population structure of insect fauna infesting stored maize along its value chain in order to guide the development of management strategies.

Materials and Methods

A survey was conducted between December 2017 and March 2018 when there was grain in storage and when infestation and grain damage levels were most likely to be serious after maize grain spending at least 5 months in storage since harvest. A total of 150 farmers, 30 trader/retailer stores in villages and townships, and 15 maize milling facilities were randomly selected from north western, eastern and central regions of Uganda, and sampled for presence of storage pests. From a maize storage facility at each sampling point, grain was collected from the top, on the sides, in the centre, and at the bottom, combined and a subsample of 100g of grain taken. The subsamples were each put in a sealed plastic-bottles punctured with pinholes and labelled with sample number. At each sampling point, specific information such name of farmer/ trader/retailer/mill, date of sampling, time of grain spend in storage, treatments to control pest infestations, and which pests among those sighted or otherwise the respondent perceived as most important, were recorded.

In the laboratory, each grain sample was sieved over a 2 mm mesh sieve and all fractions were examined. Insects were removed, counted and grouped according to order or genus and were preserved dry as pinned collections or in 75% alcohol. The different fractions of grain samples were reconstituted, re-bagged, and were held at room temperature to determine any internal infestation or parasitism. After about one month, these samples were re-examined and any emerged insects were recorded as previously. Based on their relative abundance in grain samples, the status of insects of each species was noted as being: very common when they were numerous and recorded from all samples; common when they were few but recorded from all samples; uncommon when they were few in number and recorded from some of the samples only; uncertain when it was not possible to handle for counting (for example mites); and unusual when the species is not known as a pest of stored products and was recorded from one or two samples only. The samples of insects and other arthropods obtained during both inspection periods are kept at the School of Agricultural Sciences Makerere University for further confirmation of identification.

Results and Discussion

The species of arthropods recorded on stored maize are listed in Tab. 1. Five species of Coleoptera and three species of Lepidoptera were preliminarily identified at the School of Agricultural Sciences Makerere University. Among Coleoptera, *Sitophilus* spp., *Tribolium* spp., *Rhizopertha dominica* and *Cryptolestes* spp. were the most common and widespread pests. One species of Coleoptera was vaguely identified as *Prostephanus truncatus* (large grain borer) but only one insect in one sample was recovered. The species of Lepidoptera that were recovered from the maize samples included *Sitotroga cerealella*, *Ephestia cautella* and *Plodia interpunctella*. These were dominant but only widespread in maize grain samples collected from village trader/retailer/milling premises. There were many other coleopteran pests, possibly mites, thysanura and diptera that were recovered in store refuse within the farmer stores and village trader/retailer/milling premises that were considered mostly secondary pests, and were not identified.

Sitophilus spp. was the most common and perhaps the most destructive of all the insect pests recorded (Tab. 2). Most of the pest species were recovered from grains that have been broken or damaged by *Sitophilus* spp., *S. cerealella* and *R. dominica* that are the primary pests, and thus considered secondary pests. These species that were recovered are cosmopolitan pests in stored products and not unique to Uganda. However, nationwide surveys may be necessary to determine the diversity of species of pests associated with stored maize and other stored produce in Uganda. This study did not attempt to estimate the exact losses caused by the major pest species in maize. It is important to determine the losses associated within the different types of stored produce so as to guide development of integrated pest management system.

Tab. 1: List of arthropod pests and their status in maize stored at on-farm and in village trader/retailer/milling premises in north western, eastern and central regions of Uganda between December 2017 and March 2018

Insect species*	Incidence and Spread		
	Central	North western	Eastern
Coleoptera			
Cyptolestes spp	+	++	+++
Oryzaephilus spp	+	+	+
Rhizopertha dominica	+	+++	+++
Sitophilus spp	+++	+++	+++
Tribolium spp	++		+++
Prostephanus truncatus		?	?
Lepidoptera			
Ephestia cautella	+	+++	++
Plodia interpunctella	+	++	+++
Sitotroga cerealella	+	+++	+++
Others		++	+++

Re-drying at farm level is the common practice for managing pests, as most farmers reported that it reduces insect populations, with many of the winged insects flying away and the coleopteran insects crawling away from the grain under the hot sun. However, this practice exposes the grain to re-infestation, and increased damage in continued storage. The lack of a differentiated market, whereby better quality would fetch premium price, discouraged farmers to invest in postharvest loss reducing technologies. Depending on the quantities produced and the desperate need of income by the farmer, most farmers to sell their grains immediately after harvest whereby the drying process may also be hurried through. Subsequently poor quality produce enters the trading component of the value chain and thus the commodity fetching very low prices. At trader/retailer stores in villages and townships, grain was not held at all early in the season due to demand, and most traders sold their stocks as soon as there was the next bulk buyer. This was also a way to build capital to buy more grain later in the season. Where grain was held for some time in anticipation of improvement in price, there was no partitioning of the maize grain brought into storage the peak of harvesting that was in most cases in excellent quality from the later stocks brought in several months after harvest that were infested with diverse insects. At trader/retailer stores in villages and townships, chemical dusts either spread on the bags or admixed with grain before bagging was the most common pest management practice. No milling premise was observed to hold stocks of maize grain. The pests recovered within these sampling points were in grain dust on the floors, walls and roofs of the premises.

Tab. 2: Mean number (per 100g) of insect pests recorded from stored maize samples collected at on-farm and in village trader/retailer/milling premises in north western, eastern and central regions of Uganda between December 2017 and March 2018

	Central	North western	Eastern
Coleoptera			
Sitophilus spp	85.3 ± 7.6	63.1 ± 6.8	51.4 ± 6.8
Rhizopertha dominica	33.1 ± 7.2	37.0 ± 3.2	82.4 ± 6.8
Tribolium spp	10.8 ± 2.6	50.0 ± 1.7	19.5 ± 3.7
Cyptolestes spp	7.4 ± 2.1	12.1 ± 1.6	23.4 ± 2.0
Lepidoptera			
Sitotroga cerealella	2.5 ± 1.1	1.1 ± 0.3	6.2 ± 0.9
Plodia interpunctella	3.8 ± 1.5	5.9 ± 0.6	0.7 ± 0.2
Ephestia cautella	5.6 ± 1.6	3.4 ± 1.2	2.7 ± 1.6

± SE

Based on the insect species diversity, dominancy, spread, and greatest potential for damage, the critical point of pest management is at the farm level. Postharvest control of insect pests should be an integral part of maintaining safe, high quality, abundant produce domestically and for trading in the country. For example, the necessity to variously demonstrate appropriate postharvest technologies such as mechanical crop shelling, solar dryers, and improved storage (e.g. hermitic bags and insecticide incorporated polypropylene bags) to farmers and traders. In order to promote adoption of these technologies, there is need for behaviour change communication campaign, and to conduct short-term trainings to create awareness and build a cadre of local postharvest specialists among extension workers as part of long-term capacity building in on-farm grain handling and storage; stored grain management; and application of basic food safety principles. There is also need to improve the operation environment, for example, strengthening farmer associations/community-based organizations to increase access to postharvest tools, equipment, packages, supplies; and facilitate development of well-structured commodity value chains and postharvest management and handling operations in the country. These associations/community-based organizations would establish postharvest service centres and Agribusinesses which offer a combination or all of the following services: harvesting, de-husking, drying, shelling, cleaning, storage, provision of agricultural inputs, and credit facilities. These postharvest handling services could make it possible to produce large quantities of consistently high quality commodities which would then facilitate value addition and bigger profit margins for the smallholder farmers. At trader/retailer stores in villages and townships, there is need for improved sanitation in the stores, and ability to rotate the produce in store according to the "first in - first out" principle in order to prevent over-storage.

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