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Quality and mycotoxin contamination of maize stored in air-tight containers in rural farm stores: data from two semi-arid zones in Kenya and Tanzania

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Abstract

Hermetic containers have been promoted in recent years for chemical-free grain storage among smallholder farmers. In the context of grain quality, the influence of maize storage and pre-storage practices (harvesting time, dehusking, drying, and shelling method) on performance of air-tight bags was investigated in the semi-arid regions of south eastern Kenya and northern Tanzania. Completely randomised trials were conducted in farmer-own stores; shelled maize was filled in air-tight bags or woven polypropylene (PP) bags and stored for 30-35 weeks. Insect damage, physical grain quality, mould infection were evaluated at 6-7 weeks intervals, and mycotoxin contamination was examined at onset, mid, and end of storage. Maize stored in hermetic bags was generally free from insect infestation, while PP bags permitted profuse build-up of insect populations causing grain damage of up to 82%. Total aflatoxin contamination of maize stored at moisture content below 14% increased significantly in the PP bags (5 - 8 folds) but not in the air-tight ones. Harvesting, drying and shelling practices significantly influenced the quality of maize stored in hermetic bags, resulting in sorting losses of 6-23 kg/100 kg after 6-8 months of storage. Since sorting is an important operation for improvement of food value and market quality, such losses would significantly lower the benefits of air-tight storage. Pre-storage practices of sorting, cleaning and moisture verification by farmers have impact on overall performance of air-tight storage.

On-Farm Maize Insect Pest and Mycotoxin Levels in Ghana

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Abstract

Maize post-harvest losses are perennial in Ghana but reliable comparative information on on-farm losses of maize produced in the Middle and Northern Belts of Ghana is lacking. Two studies were conducted from September 2015 to February 2016 to identify factors contributing to on-farm losses of maize in these two Belts. In the Northern Belt, the study was conducted in six communities including Adubiyili, Diari, Pong-Tamale, Savelugu, Toroyili and Zamnayili; and in the Middle Belt, in Ejura, Sekyedumase and Amantin communities. Moisture content, percent weight loss, percent insect damaged kernels (IDK) on numerical basis (%IDK_{nb}) and percent IDK by weight basis (%IDK_{wb}), insect pest abundance, and mycotoxin levels were estimated. Moisture content values of maize at pre-harvest and heaping stages in all nine communities were below 15%. *Sitophilus zeamais*, *Sitotroga cerealella*, *Cathartus quadricollis*, and *Carpophilus dimidiatus* were found to attack maize on-farm in communities in the Middle Belt, but no adult insect pests were collected on pre-harvested maize in the Northern Belt. The %IDK_{nb} values on-farm in all nine communities were < 2% per 250 g. Mean aflatoxin levels below 15 ppb were obtained from pre-harvested maize in both regions but levels above 15 ppb were obtained from heaped maize on-farm. Fumonisin levels of maize were below 4 ppm on pre-harvested and in heaped maize in both regions. Results show that heaping maize on-farm increases aflatoxin levels beyond the acceptable threshold level and should not be practiced.

Keywords: insect infestation, aflatoxin, fumonisin, maize post-harvest loss, food security

1. Introduction

In Ghana, maize accounts for 50–60% of cereal production, with major producing areas located within the middle to southern parts of the country (CSIR-SARI/AGRA, 2014). Maize post-harvest losses in Ghana are estimated to be 35% (Edusah, 2007) which is a threat to food security. The major causes of maize post-harvest losses are grain moisture content, environmental conditions and biological agents, mainly insect pests and mold. Insect pests cause both qualitative and quantitative losses to maize and can facilitate dissemination of fungal spores (Hell et al., 2010). Mold and fungal infections can lead to mycotoxin contamination and this may occur throughout the maize value chain (Enyiukwu et al., 2014). From 2015 to 2016, separate surveys were conducted in the Middle and Northern Belts of Ghana to assess post-harvest losses of maize on-farm and at post-drying stages in order to identify mitigating strategies. This paper sought to provide comparative information on the factors contributing to post-harvest losses of maize on-farm in the two Belts (Middle and Northern Belts).

2. Materials and Methods

In the Middle Belt of Ghana, the study was conducted in three principal maize growing districts of Ejura, Sekyedumase and Amantin. The study covered the periods September–mid-October 2015 and late-December 2015–mid-February 2016. These periods corresponded with harvest time for the major and minor cropping seasons, respectively. A three-factor factorial-RCBD design of the factors cropping season, district and sampling stage with 2x3x3 levels (two cropping seasons: major and minor; three districts: Ejura, Sekyedumase and Amantin; and three sampling stages: field, ground-pile and post-drying) was used. Farmers within sampling location represented replications for the district in a cropping season. White maize varieties (Obatanpa,aborohomaand OBT) the most widely cultivated varieties in the Middle Belt of Ghana were sampled from selected farmers. Samples were taken from 51 maize farms. The three sampling stages were assigned to each randomly selected maize farm for a maize cropping season. In the Northern Belt, the study was conducted in farms in two districts of Central Gonja and Savelugu-Nanton in the Tamale area of Northern Region, Ghana. The locations selected were Adubiyili, Toroyili and Zamnayili in Central Gonja district; Diari, Pong-Tamale and Savelugu in Savelugu-Nanton district. Five farmers were chosen from each location. This study spanned the period October to December 2015 in the Northern Region, and this period corresponded with harvest time for the single maize season in the Northern Belt. In both belts, field sampling was performed by sampling mature cobs either before or during harvesting. From each farm 30 cobs were randomly collected from three parts of the field. Cobs from each part of the farm were de-husked and kept in three sealed and labelled plastic bags (39 cm x 25 cm) with each bag containing 10 de-husked cobs. De-husking was carefully done to avoid escape of insects on cobs. Cobs in each bag were hand shelled into a basin, mixed thoroughly and 500 g weighed out for moisture content, insect and aflatoxin and fumonisin data. Maize samples for mycotoxin test were kept in a portable cooler to reduce further growth and development of fungi. For ground-pile/heaping stage sampling, similar protocols as the field sampling stage were used for sampling and data collection, however, samples were taken from heaps of cobs piled on the ground in the farm fields after harvest. With respect to post-drying sampling stage, maize was sampled after cobs had been mechanically shelled and kernels sun-dried for storage or market. Dried maize grains either on tarpaulin or in store were divided into three different sections. A 2-kg sample was taken from each division by sub-sampling ten 200 g of maize from a sampling section. Three 500 g sub-samples were taken from each of the three 2 kg samples, kept in sealed and labelled plastic bags for data collection. Mycotoxin (aflatoxin and fumonisin) analyses were performed using AgraStrip® WATEX (aflatoxin) and AgraStrip® Total Quantitative Fumonisin (COKAS3000A) test kits provided by Romer Labs®, Inc. Union, MO, USA. In both tests, sample grinding, extraction, solute preparation and test procedures were done in accordance with the manufacturer's instructions (Romer Labs Methods, romerlabs.com). Complete details of these surveys can be found in Danso et al. (2017).

Statistical analyses were performed with SAS Version 9.4 (SAS Institute, Cary, NC). Data were analyzed by location (district) because interest was primarily understanding the effects of stage and cropping season on response variables whose data were collected.

3. Results

In both Belts, moisture content of maize at all three sampling stages was < 15%. In the Middle Belt, *Sitophilus zeamais* (Motschulsky), *Sitotroga cerealella* (Olivier), *Cathartus quadricollis* (Guerin-Meneville) and *Carpophilus dimidiatus* (Fabricius) were the dominant insect species that were recovered from maize on-farm but in the Northern Belt, there were no insect pests on maize at the field stage and only a few larvae were found in heaped maize. In both Belts, mean percentage insect damaged kernels (%IDK_{nb}) recorded across locations were below the 5% threshold set by Ghana Standard Authority (GSA) for commerce. The %IDK_{nb} values on-farm in all nine communities were < 2% per 250 g and mean maize weight losses of < 1% were recorded in all the communities. In the Middle Belt, mean %IDK_{nb} recorded across the locations in both cropping seasons ranged between 0.35–0.82% while 0.35–1.82% were recorded in the Northern Belt. However, in both Belts, %IDK_{nb} was significantly lower at field stage than at both the heaped and post-drying stages. Mean aflatoxin levels below 15 ppb were recorded from pre-harvested maize in both Belts but levels above 15 ppb were recorded from heaped maize on-farm. Fumonisin (ppm) levels of maize were below the recommended threshold of 4 ppm on pre-harvested and in heaped maize in both Belts.

4. Conclusion

The data presented in this comparative study show that more insect pests attack pre-harvested maize in the Middle Belt compared to the Northern Belt of Ghana. Interestingly, comparable insect damage and weight loss of maize occur in both Belts. Data also show that heaping maize on-farm increases aflatoxin levels beyond the acceptable threshold level and should not be practiced.

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