AKOWUAH J. O., MENSAH L. D., CHAN C. AND ROSKILLY A. (2015). EFFECTS OF PRACTICES OF MAIZE FARMERS AND TRADERS IN GHANA ON CONTAMINATION OF MAIZE BY AFLATOXINS: CASE STUDY OF EJURA-SEKYEREDUMASE MUNICIPALITY. AFRICAN JOURNAL OF MICROBIOLOGY RESEARCH, 9(25); 1658-1666, DOI: 10.5897/AJMR2014.7293; ISSN 1996-0808

AMANOR-BOADU VINCENT (2012). MAIZE PRICE TRENDS IN GHANA (2007-2011). METSS-GHANA RESEARCH AND ISSUE PAPER SERIES NO. 01.

AZADI M. S. AND YOUNESI E., 2013. The effect of storage on germination characteristic and enzyme activity of sorghum seed. Journal of Stress Physiology & Biochemistry, 9(4): 289-298.

CARVALHO, E.R.; OLIVEIRA, J.A.; MAVAIEIE, D.P.R.; SILVA, H.W.; LOPES, C.G.M. 2016: PRE-PACKING COOLING AND TYPES OF PACKAGES IN maintaining PHYSIOLOGICAL QUALITY OF SOYBEAN SEEDS DURING STORAGE. JOURNAL OF SEED SCIENCE, V.38, N.2, P.129-139; HTTP://DX.DOI.ORG/10.1590/2317-1545V38N2158956

CHAKRAVERTY, A., 1988. POST-HARVEST TECHNOLOGY OF CEREALS, PULSES AND OILSEEDS; OXFORD & IBH PUB. CO.: NEW DELHI, INDIA.

CORZO, O., N. BRACHO, A. VASQUEZ and A. PEREIRA (2010). Determination of suitable thin layer model for air drying of coroba slices (Attelea maripa) at different air temperatures and velocities. Journal of Food Processing and Preservation 34:587-598.

FOLARANMI JOSHUA (2008). DESIGN, CONSTRUCTION AND TESTING OF SIMPLE SOLAR MAIZE DRYER. LEONARDO ELECTRONIC JOURNAL OF PRACTICES AND TECHNOLOGIES. ISSUE 13, P. 122-130.

FUDHOLI, A., MAT, S., BASRI, D., F., RUSLAN, M., H. AND OPIAN, K., 2016. PERFORMANCES ANALYSIS OF GREENHOUSE SOLAR DRYER WITH HEAT EXCHANGER. CONTEMPORARY ENGINEERING SCIENCES, VOL. 9, 2016, NO. 3, 135 – 144

HARTMANN F., CESAR P., (2016). The effect of drying temperatures and storage of seeds on the growth of soybean seedlings. J. Seed Sci. [online]., vol.38, n.4, pp.287-295. ISSN 2317-1537. http://dx.doi.org/10.1590/2317-1545v38n4161866.

Hassan M. M., (2010). Drying and quality evaluation of paddy seeds in hybrid dryer. Accessed on 20th March, 2018. Available at www.saulibrary.edu.bd/daatj/public/index.php/.../BAU201001_14-fm_5.pdf.

INTERNATIONAL SEED TESTING ASSOCIATION (1985). International Rules for Seed Testing 1985. Seed Science and Technology 13 (2): 299-520.

KAAYA A. N. AND KYAMUHANGIRE W., (2010). Drying maize in using biomass-heated natural convection dryer to improve grain quality during storage. Journal of Applied Sciences 10(11): 967-974

KADER, M. A., 2005. A COMPARISON OF SEED GERMINATION CALCULATION FORMULAE AND THE ASSOCIATED INTERPRETATION OF RESULTING DATA. JOURNAL & PROCEEDINGS OF THE ROYAL SOCIETY OF NEW SOUTH WALES, VOL. 138, P. 65–75.

KIRLEIS, A. W. AND STROSHINE R. L., (1990). Effects of hardness and drying air temperature on breakage susceptibility and dry-milling characteristics of yellow dent corn. Cereal Chem. 67(6):523-528.

Lewicki, P.P.; Pawlak, G (2003). Effect of drying on microstructure of plant tissue. Drying Technology, 21(4), 657–683.

MENEZES, N.L.; CICERO, S.M.; VILLELA, F.A.; BORTOLOTTO, R.P. (2012). Using x-rays to evaluate fissures in rice seeds dried artificially. *Revista Brasileira de Sementes*, v.34, n.1, p.70-77. http://www.scielo.br/pdf/rbs/v34n1/a09v34n1.pdf

OWOLADE, O. F.1, ALABI, B. S.1, ENIKUOMEHIN, O.A. AND ATUNGWU, J. J., 2005. EFFECT OF HARVEST STAGE AND DRYING METHODS ON GERMINATION AND SEED-BORNE FUNGI OF MAIZE (ZEA MAYS L.) IN SOUTH WEST NIGERIA. AFRICAN JOURNAL OF BIOTECHNOLOGY, 4 (12): 1384-1389.

PLANT PROTECTION ACT (1976). Plant Protection Act, Provisions Relating to Seed and Seed Samples (1976) Act no. 53 of 1976.

SADJAD ABASI AND SAEID MINAEI (2014). EFFECT OF DRYING TEMPERATURE ON MECHANICAL PROPERTIES OF DRIED CORN, DRYING TECHNOLOGY: AN INTERNATIONAL JOURNAL, 32:7, 774-780. Available at http://dx.doi.org/10.1080/07373937.2013.845203

SCOTT, S., JONES, R. AND WILLIAMS, W., 1984. REVIEW OF DATA ANALYSIS METHODS FOR SEED GERMINATION. CROP SCIENCE, 24, 1192–1199.

SEKYERE C.K.K., F.K. FORSON, F.W. ADAM, 2016. EXPERIMENTAL INVESTIGATION OF THE DRYING CHARACTERISTICS OF A MIXED MODE NATURAL CONVECTION SOLAR CROP DRYER WITH BACK UP HEATER. RENEWABLE ENERGY 92 (2016) 532 – 542

TIBEBU, T. B., OBENG, G. Y., MENSAH, E. AND SMITH, A., 2015. SOLAR DRYER WITH BIOMASS BACKUP HEATER FOR DRYING FRUITS: DEVELOPMENT AND PERFORMANCE ANALYSIS. JOURNAL OF SCIENCE AND TECHNOLOGY, VOL. 36, NO. 2, PP 10-25.

TOGRUL I. T. AND PEHLIVAN D. (2004). MODELLING OF THIN LAYER DRYING KINETICS OF SOME FRUITS UNDER OPEN-AIR SUN DRYING PROCESS. JOURNAL OF FOOD ENGINEERING, 65: 413-425

TONUI S. K., 2014. DESIGN AND EVALUATION OF SOLAR MAIZE GRAIN DRYER WITH A BACK-UP HEATER. MSC. THESIS, DEPARTMENT OF AGRICULTURAL AND BIOSYSTEMS ENGINEERING UNIVERSITY OF NAIROBI.

ULLMANN R.; RESENDE O.; CHAVES T.H.; OLIVEIRA D.E.C.; COSTA, L.M. (2015). Physiological quality of sorghum seeds subjected to drying under different air conditions. Brazilian Journal of Agricultural and Environmental Engineering, v.19, p.64-69.

Weiss, W. and Buchinger, J. (2015). Solar drying. Accessed on 28th March, 2018. Available at- http://www.aee-intec.at/0uploads/dateien553.pdf

YALDIZ, O. AND ERTEKIN C., (2001). Thin layer solar drying of some different vegetables. Drying Technology 19: 583-596.

Evaluation of AgroZ Hermetic Storage Bag against insect pests on stored maize

Kimondo Mutambuki, Paddy Likhayo, John Mbugua, T. Warigia

Kenya Agricultural Research and Livestock Research Organisation(KALRO), Food Crops Research Institute-Kabete, P O Box 14733- 00800, Nairobi, Kenya

*Corresponding author: mutambukikimo@yahoo.com

DOI 10.5073/jka.2018.463.013

Abstract

A study on AgroZ airtight bag was conducted against two major storage insects under simulated farmers' storage practice. Two (2) lots of 50kg white maize of Pioneer variety were put into AgroZ bag and polypropylene woven bag to serve as a control. Four replications of each bag type were used. In each bag, 50 adults of unsexed larger grain borer, *Prostephanus truncatus*, and maize weevil, *Sitophilus zeamais*, each were introduced. AgroZ bag had one liner placed inside polypropylene bag to provide support and handling convenience. Each liner had been tested for air tightness before use. The AgroZ bags were securely tied to ensure airtightness thus leading to a hermetic environment. The bags were then randomly placed in a barn on pallets in a randomised complete design (RCD). Sampling was done every 4 weeks up to 24 weeks. A 500g sample was initially taken using a compartmented long spear probe from each bag for baseline data, and subsequent ones at 4, 8, 12, 20 and 24 weeks. Repeated sampling from the same storage device reflected farmer practices of opening the device at regular intervals to draw grain for use as household food. Gas analysis in AgroZ bags showed oxygen level dropping rapidly to 7% within 4 weeks and later increased gradually to 10% at 12 weeks. Conversely, carbon dioxide level increased sharply to 10% and declined gradually to 9% over the same period. The number of insects and percentage damaged grains between AgroZ bag and polypropylene bag significantly differed from 12th week to 24th week. AgroZ bag outperformed the polypropylene bag commonly used by farmers and conveniently protected maize from insect infestation within the 6-month storage period.

Introduction

Maize (*Zea mays* L.) is a major grain staple in Sub-Saharan Africa that provides calories and income for many households (Zia-Ur-Rehman, 2006). Whereas the crop is harvested every season, substantial amount of the grain is lost to insect pests during storage because to control these pests remains a challenge to resource-poor smallholder farmers. This is aggravated by lack of effective, appropriate and affordable storage devices (Baributsa *et al*., 2014). As a result of insect feeding, damage, and contamination, the volume of stored grain and quality, grain value, and marketability is reduced (Affognon *et al*., 2015). To avoid the risk of losing the harvested crop to insect pests, some farmers sell their maize early at low price while others treat it with dilute insecticidal dusts, but satisfactory protection is never achieved (Obeng-Ofori, 2011). The major insect pests of stored maize are the larger grain borer, *Prostephanus truncatus* (Horn), and the maize weevil, *Sitophilus zeamais* Motschulsky (DeGroote *et al*., 2013). The former is the most damaging pest, and in endemic areas causes weight loss estimated at 30% while the maize weevil causes 10-20% weight loss when untreated maize is stored in traditional structures (Boxall, 2002; Mutambuki & Ngatia, 2012; Likhayo *et al*., 2016).

Hermetic storage technology offers farmers' effective alternative for protection of stored maize against insect pests. The technology functions by creating modified atmospheres around the grains through physical and biological means to retard the activity and survival of insects in the stored grain (Anankware *et al*., 2012). In recent years, the technology has received much attention by the private sector as the means of safeguarding stored grain because it is cheaper compared to metal silo and safe (Murdock et al., 2003). Currently, there are two hermetic bags available commercially, namely, Purdue Improved Crop Storage (PICS) and GrainPro bags. Whereas these bags effectively control storage insect pests of crops such as maize (DeGroote *et al*., 2013), cowpeas (Moussa *et al*., 2014) and beans (Mutungi *et al*., 2015), the plastic film (liner) has been found perforated (Garcia-Lara *et al*., 2013; Martin *et al*., 2015; Likhayo *et al*., 2016) thus compromising the integrity of the bags. With changing behaviour of insect pests, it is imperative to continually evaluate novel and newer hermetic bags to address this concern. Hermetic grain storage bags of 100kg or less capacity offer smallholder farmers the desired flexibility and control of their produce. AgroZ bag is a low permeability plastic bag developed by A to Z Textile Mills Ltd (Tanzanian manufacturer) for the storage of maize and pulses against postharvest insect pests.

In an effort to contribute to the Public-Private Partnership, the manufacturer submitted samples of AgroZ bags to KALRO-Kabete for local validation through a structured evaluation. The aim of this study was therefore to validate the efficacy of the bag in protecting stored maize against the larger grain borer and other important storage insect pests under field conditions.

Materials and methods

The field trial was conducted at Kiboko sub-centre, about 200 km from KALRO-Kabete, along Nairobi Mombasa highway. The choice of the site was due to prevalence of the larger grain borer and a barn where simulation of farmers' storage condition was adopted. Two (2) lots of 50kg white maize of Pioneer variety (H614D) that had been fumigated was put into AgroZ bag and polypropylene (farmer) bag to serve as a control. Four replications of each bag type were used. In each bag, 50 adults of unsexed *P. truncatus* and *S. zeamais* each (based on 1 adult insect per kg) were introduced. AgroZ bag had one liner placed inside polypropylene bag to provide support and handling convenience. Prior to placing the liners in polypropylene bags, they were tested for air tightness or leakage by filling the air to form a pouch before compressing them with both hands. The AgroZ bags were securely tied to ensure airtightness thus leading to a hermetic environment. Any bag that leaked was discarded. The bags were then randomly placed in a barn on pallets (dunnage) in a randomised complete design (RCD). Sampling was done every 4 weeks up to 24 weeks. A 500g sample was initially taken using a compartmented long spear probe from each bag for baseline data, and subsequent ones at 4, 8, 12, 20 and 24 weeks. Repeated sampling from the same storage device reflected farmer practices of opening the device at regular intervals to draw grain for use as household food.

Each grain sample was sieved to separate dust from insects and grain. Grain moisture was determined using Dickey-John Multi-Grain® moisture tester (Dickey-John Corporation, Aurburn, IL, USA) (wet basis). Moisture content was measured at the beginning of experiment and at every sampling time. Three readings of each sample were taken, and the average recorded. The sample was then divided using a riffle divider until four sub-samples of approximately 65g were obtained. Grains in three of the sub-samples were sorted into undamaged, damaged, discoloured, and broken grain categories which were counted and weighed. The damaged grain was expressed as a percentage of the total grain in the sub-sample. The fourth sub-sample was reserved for reference. Percentage grain moisture content, number of live adult insects, and percentage grain damage were parameters used to judge the efficacy of each treatment. Upon termination of the trial, the hermetic bags were inspected for perforation (holes) made by adult *P. truncatus* and the number of holes recorded.

Statistical analysis

The number of insects was $\log_{10}$(count +1) transformed, while percentage moisture content and damaged and discoloured grain data were square-root transformed in order to stabilize the variances. The transformed data were analysed using General Linear Model procedure of GenStat Release 12.1 (VSN International Ltd 2009), with bag type and storage period as main effects. Insect counts, grain moisture content, and percentage damaged grains at each time-point post-treatment were the response variables. Significant differences between the means were separated by Tukey test at $P<0.05$. However, for ease of understanding untransformed means are presented. The means of gas composition levels at each sampling time-point were computed.

Results

Effect of bag type on grain moisture content

There were significant differences ($F_{1, 33}=16.43$; $P<0.001$) in grain moisture content between bag type and storage period ($F_{5, 33}=21.82$; $P<0.001$) but the interaction was not significant ($P>0.05$). Although significant differences were observed, the moisture content did not change markedly between bag types throughout the entire storage period and, remained below the recommended limit of 13.5% (Table 1). The grains stored in polypropylene bag (12.1%) and AgroZ bag (12.3%) recorded almost same moisture contents after 24 weeks of storage, respectively.

Table 1: Mean percentage (±SE) grain moisture content changes during storage

Bag Type	Storage period (weeks)					
	0	4	8	12	20	24
AgroZ	12.3 ± 0.2cd	11.9 ± 0.0a	12.4 ± 0.0cd	12.6 ± 0.0d	12.3 ± 0.0cd	12.3 ± 0.0bcd
Polypropylene	12.2 ± 0.0bcd	11.6 ± 0.0ab	12.1 ± 0.1bc	12.5 ± 0.0cd	12.1 ± 0.1bc	12.1 ± 0.0bc

Means within the same column or row followed by the same letter are not significantly different at P = 0.05 level (Tukey test)

Effect of bag type on adult insect counts (both live and dead)

In this study *P. truncatus*, *S. zeamais*, and *Tribolium castaneum* (Herbst) were detected. At the start of the trial, the maize did not have emergent infestation. Interaction effect between treatment and storage duration was significant ($F_{5,\ 33}$ =73.6; P<0.001). AgroZ bags supressed increase in insect population compared to control (polypropylene) bags. On all sampling occasions starting at 12 weeks, least number of adult insects was recorded in the grains stored in AgroZ bags (Table 2). Significant numbers of insects became evident starting from 12th week of storage in the polypropylene (4) bags (Table 2). At the end of the trial, holes perforated by *P. truncatus* were detected in AgroZ bags. Two replicates had 3 and 4 holes each while the other 2 had no holes hence only half of the plastic liner bags used were perforated.

Table 2: Mean number (±SE) of adult insects (both live and dead) per grain sample

Bag Type	Storage period (weeks)					
	0	4	8	12	20	24
AgroZ	0 ± 0f	2 ± 0de	1 ± 0ef	2 ± 1d	2 ± 1de	1 ± 0def
Polypropylene	0 ± 0f	1 ± 0ef	2 ± 2de	4 ± 0c	10 ± 0b	16 ± 1a

Means within the same column or row followed by the same letter are not significantly different at P = 0.05 level (Tukey test)

Effect of bag type on grain damage

There were significant interaction differences ($F_{5,\ 33}$=185.3; P<0.001) between treatments and storage duration. Grain damage for the treatments is presented in Table 3. At the start of the trial, the maize showed little damage. From 12 weeks' storage duration, no further grain damage was detected in AgroZ bags (Table 3). In contrast, grain damage in the control bags increased steadily from 8th week of storage and reached 11.7% at the end of the trial. If by the 24th week the damage was adjusted by subtracting the baseline damage, actual damage for AgroZ bag was only 1.1% compared to 10.4% for polypropylene bags.

Table 3: Mean percentage ((± SE) grain damage due to insect infestation during storage

Bag Type	Storage period (weeks)					
	0	4	8	12	20	24
AgroZ	1.6 ± 0.2hi	2.0 ± 0.2gh	2.2 ± 0.1efg	2.5 ± 0.2ef	2.8 ± 0.2de	2.7 ± 0.2de
Polypropylene	1.3 ± 0.2i	1.8 ± 0.1ghi	3.1 ± 0.2d	5.7 ± 0.1c	8.4 ± 0.2b	11.7 ± 0.2a

Means within the same column or row followed by the same letter are not significantly different at P = 0.05 level (Tukey test)

Changes in gas composition in AgroZ bag

Although the storage period was 24 weeks, gas composition levels in AgroZ bags was only measured for 12- week storage period (Figure 1). Gas composition levels determined after closing the bags at the onset of the storage were 20.7 ± 0.0% oxygen and 0.9 ± 0.0% carbon dioxide. Oxygen level dropped rapidly to 6.7 ± 0.1% within four weeks and thereafter increased gradually to 10.7 ± 0.1% at 12 weeks. Carbon dioxide level on the other hand increased sharply to10.3 ± 0.1% then declined gradually to 8.9 ± 0.1% within the same period.

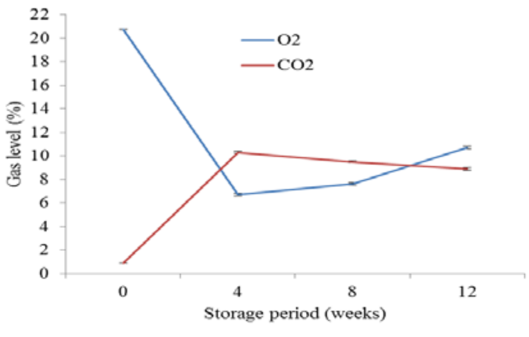

Figure 1: Oxygen and carbon dioxide levels in AgroZ bag over 12 – week of maize storage. Data shown are means ± standard error for four replications.

Discussion

Smallholder farmers store their maize grain to assure supply between the harvests. However, factors such as use of improved susceptible varieties and the spread of the exotic storage insect pest like the larger grain borer (*P. truncatus*) could negatively impact effective storage practices. Despite farmers applying insecticides and traditional protective measures, fewer achieved satisfactory control of the insect pests. Grain damage due to insect infestation is a serious concern that threatens food security and livelihood of rural farmers.

The modified environment created by respiration of th maize grains and insects effectively suppressed insect survival and as a consequence stopped grain damage. Low oxygen levels and enhanced carbon dioxide of inter-granular atmosphere is the basis of insect infestation suppression in hermetic storage. Evidently, extreme oxygen depletion and carbon dioxide build-up levels were not achieved in the AgroZ bags probably due to opening of the bags during sampling. The depletion of oxygen and build-up of carbon dioxide is a function of, among other elements, storage containers; insect population; grain moisture; and gas-tightness. Development of a low oxygen environment is very slow in the absence of insects and predominance of dry grains (<13% moisture content), even in containers where high standard of gas-tightness is achieved. This is attributed to low aggregate oxygen demand in the containers (Moreno-Martinez *et al*., 2000). Other studies, however, reported gradual decrease of oxygen to 8.4% within 30 days in clean maize stored without insect infestation under hermetic conditions (Moreno-Martinez *et al*., 2000). Further, Ng'ang'a *et al*. (2016) reported that oxygen level dropped to 4.9% and carbon dioxide increased to 10.5% within the first seven weeks of on-farm storage of maize in PICS bags. The gas composition levels reported in this study did not differ markedly from those documented by these researchers suggesting hermeticity of AgroZ bags is comparable to that of PICS bags.

This study has demonstrated significant grain damage in maize stored in polypropylene bags compared to that which was stored in AgroZ Plus bags. A study by Njoroge *et al*. (2014) reported 3.4% grain damage when maize (variety H614D) was stored in PICS bags in the presence of *P. truncatus* at ambient conditions for six months. The same maize variety was used in the current study, and a difference in grain damage reported (0.9%) is very small to be important. Therefore, the grain damage recorded by AgroZ bags compares well with that of PICS bags. Although insect pest multiplication was not very high in the control bags as expected, the grain damage levels observed were mainly a result of insect infestation attributed to favourable ambient conditions. Conversely, multiplication of insect pests was drastically reduced in AgroZ bags because of the modified environment (low oxygen and high carbon dioxide levels) within the bags.

Upon termination of the trial, inspection showed physical damage (perforation) of AgroZ bags. These bags are made of tougher polyethylene (PE), 90 µm thick, with good gas and water barrier properties. Therefore, grain volatiles would not be released to the outside to elicit movement of insects into the bags looking for food while the insects inside the bags died due to depleted oxygen levels (hypoxia). Although the holes were evident to the naked eye, their examination by use of hand-held magnifying glass showed that the scratch and tear were less marked around the holes on the side from which the insects perforated the liner, an indication of exit holes (Riudavets *et al*., 2007). The holes might have been made by *P. truncatus* attempting to escape from the bags when exposed to oxygen-depleted environment. *P. truncatus* has the ability to bore through hard materials such as a 35mm thick plastic (Li, 1988). The holes were made near the bottom of the bags. The holed bags therefore failed to attain air-tight conditions resulting in ineffective control of the storage pests. The observation is in agreement with that made by Ognakossan *et al*. (2013 – not in References) when maize was stored in PICS bags for 150 days and 180 days in SuperGrain™ bags (De Groote *et al*., 2013). Cowpea bruchid *Callosobruchus maculatus* F. (Coleoptera: Bruchidae) was found to bore PICS bags during storage in Niger (Baoua *et al*., 2012) but the hermetic condition was not completely lost because of the imperforated second liner.

Conclusion and Recommendation

AgroZ plastic bag effectively prevented insect multiplication, changes in moisture content, and grain damage as demonstrated in the field trial. Without perforations or a few as observed in the trial, the bag maintained air-tight condition leading to death of insects and hence translating into very minimal grain damage. Owing to this good performance, AgroZ bag is recommended as a storage grain protectant against storage insect pests.

Acknowledgements

The authors would like to thank KALRO centre management for providing an enabling environment for the work to be carried out and the management of the operating finances. TransGlobal Distributors Ltd provided the finances which facilitated the studies and were very timely in remitting to the centre. Our driver Mr Njuguna Kimunya who was always punctual and made sure that the car was well maintained before and after every trip.

References

Affognon H, Mutingi C, Sanginga P and Borgmeister C (2015). Unpacking postharvest losses in Sub-Saharan Africa: A Meta-analysis. *World Development* 66: 49-68.

Anankware PJ, Fatumbi AO, Afreh-Nuamah K, OBeng-Ofori D and Ansah AF (2012). Efficacy of multiple-layer hermetic storage bag for biorational management of primary beetle pests of stored maize. *Academic Journal of Entomology* 5: 47 - 53.

Baoua IB, Amadou L and Murdock LL (2012). Triple bagging for cowpea storage in rural Niger: Questions farmers ask. *Journal of Stored Products Research* 52: 86-92.

Baributsa D, Djibo K, Lowenberg-DeBoer J, Moussa B and Baoua I (2014). The fate of triple-layer plastic bags used for cowpea storage. *Journal of Stored Products Research* 58: 97-102.

Boxall RA (2002). Damage and loss caused by the larger grain borer *Prostephanus truncatus*. *Integrated Pest Management Reviews* 7: 105-121.

De Groote H, Kimenju SC, Likhayo P, Kanampiu F, Tefera T and Hellin J (2013). Effectiveness of hermetic systems in controlling maize storage pests in Kenya. *Journal of Stored Products Research* 53: 27-36.

Garcia-Lara S, Ortiz-Islas S and Villers P (2013). Portable hermetic storage bag resistant to *Prostephanus truncatus*, *Rhyzopertha dominica* and *Callosobruchus maculatus*. *Journal of Stored Products Research* 54: 23-25.

Li L (1988). Behavioural ecology and life history evolution in the larger grain borer, *Prostephanus truncatus* (Horn). PhD Thesis dissertation, University of Reading, UK. 229pp.

Likhayo P, Anani YB, Mutambuki K, Tefera T and Mueke J (2016). On-farm evaluation of hermetic technology against maize storage pests in Kenya. *Journal of Economic Entomology* 109(4): 1943-1950.

Martin DT, Williams SB, Baributsa D and Murdock LL (2015). The effect of small leaks, grain bulk and the patching of leaks on the performance of hermetic storage. *Journal of Stored Products Research* 62: 40-45.

Moreno-Martinez E, Jimenez AS and Vazquez ME (2000). Effect of *Sitophilus zeamais* and *Aspergillus chevalieri* on oxygen level in maize stored hermetically. *Journal of Stored Products Research* 36: 25-36.

Moussa B, Abdoulaye T, Coulibaly O, Baributsa D and Lowenberg-Deboer J (2014). Adoption of on-farm hermetic storage for cowpea in west and central Africa in 2012. *Journal of Stored Products Research* 58: 77-86.

Murdock LL, Dago SD, Ntoukam G, Kitch L and Shade RE (2003). Preservation of cowpea grain in Sub-Saharan Africa-Bean/cowpea CRP contributions. *Field Crops Research* 82: 169-178.

Mutambuki K and Ngatia CM (2012). Assessment of grain damage and weight loss of on-farm stored maize in highland areas of Bungoma District, Kenya. *Journal of Agricultural Science and Technology* B2: 349-361.

Mutungi C, Affognon HD, Njoroge AW, Manono J, Baributsa D and Murdock LL (2015). Triple-layer plastic bags protect dry common beans (*Phaseolus vulgaris*) against damage by *Acanthoscelides obtectus* (Coleoptera: Chrysomelidae) during storage. *Journal of Economic Entomology* 108(5): 2479-2488.

Ng'ang'a J, Mutungi C, Imathiu SM and Affognon H (2016). Low permeability triple-layer plastic bags prevent losses of maize caused by insects in rural on-farm stores. *Food Security* 8: 621-633. *DOI 10.1007/s12571-016-0567-9.*

Njoroge AW, Affognon HD, Mutungi CM, Manono J, Lamuka PO and Murdock LL (2014). Triple bag hermetic storage delivers a lethal punch to *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae) in stored maize. *Journal of Stored Products Research* 58: 12-19.

Obeng-Ofori D (2011). Protecting grain from insect pest infestations in Africa: producer perceptions and practices. *Stewart Postharvest Reviews* 3: 1-8.

Ognakossan KE, Tounou AK, Lamboni Y and Hell K (2013). Postharvest insect infestation in maize grain stored in woven polypropylene and in hermetic bags. *International Journal of Tropical Insect Science* 33: 71-81.

Riudavets J, Salas I and Pons MJ (2007). Damage characteristics produced by insect pests in packaging film. *Journal of Stored Products Research* 43: 564-570.

Rehman ZU (2006). Storage effects on nutritional quality of commonly consumed cereals. *Food chemistry* 95: 53-57.

Impact of Rodent Infestation on Availability, Safety and Nutritional value of Maize Stored On-farm in Lowland Tropical Zone of Kenya

Mutungi, Christopher.*; Edoh-Ognakossan , K.; Affognon, H.

International Institute of Tropical Agriculture (IITA)
World Vegetable Center, Samako Research Station, BP 320 Bamako, Mali
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), BP 320, Bamako, Mali.
* Corresponding author: c.mutungi@cgiar.org
DOI 10.5073/jka.2018.463.014

Rodents are the second most important storage problem after insects during on-farm maize storage in Kenya, and the greatest storage problem in the lowland tropical agro-ecological zone. However, there is limited information on the actual magnitudes of food lost, and food safety issues associated with rodent grain damage. Such information would help to improve maize postharvest management. Farmer stores were monitored over 3 months under natural infestation conditions to quantify actual weight losses due to rodents. Rodent trapping was also carried out to determine rodent species associated with the losses and their population. Additionally, samples of rodent-damaged and non-damaged grain were analysed for total mould count (CFU/g), mould incidence, total aflatoxin contamination, proximate content, and amino-acid and fatty acid profiles. Cumulative weight losses ranged from 2.2 to 6.9% in shelled maize grain, and from 5.2 to 18.3% in dehusked cobs during 3 months of storage. Rattus rattus was the only rodent species captured over the whole trapping period with a trap success rate of 0.62 -10%. Total mould count and Fusarium spp. incidence were significantly higher in rodent-damaged grains than in the non-damaged ones (P= 0.001; P= 0.011, respectively), whereas no significant difference was observed for Aspergillus spp incidence (P=0.239) and total aflatoxin contamination (P = 0.077). Contents of methionine, valine, proline and all fatty acids were significantly lower in the rodent-damaged grains.

Postharvest losses of agricultural commodities in Trincomalee, Sri Lanka

Dissanayaka Mudiyanselage Saman Kumara Dissanayaka, Abeysinghe Mudiyanselage Prabodha Sammani, Leanage Kanaka Wolly Wijayaratne*, Poorna Maheshika Samaranayaka, Lakshan Madusanka Karunarathna, Niwanthi Chandima, Ishara Maduwanthi Wijerathna, Sanjeewa Harshana, Anupama Heshani, Diluka Kalhari

Department of Plant Sciences, Faculty of Agriculture, Rajarata University of Sri Lanka, Puliyankulama, Anuradhapura, Sri Lanka.
*Corresponding author, Email: wollylk@yahoo.com
DOI 10.5073/jka.2018.463.015