

Can Triple Layer Hermetic PICS Bags Stop Heavy Infestation?

H. D. Affognon^{1*}, A. W. Njoroge¹ and D. Baributsa²

¹International Centre of Insect Physiology and Ecology, P.O. Box 30772-00100, Nairobi, Kenya

² Purdue University, West Lafayette, IN 47907, USA

*Corresponding author; E-mail: haffognon@icipe.org (H. Affognon)

Experiments were conducted at the International Centre of Insect Physiology and Ecology (ICIPE), Nairobi Kenya, to evaluate the performance of hermetic triple bagging (PICS) bags for controlling heavily infested maize with *Prostephanus truncatus* Horn and *Sitophilus zeamais* Motschulsky respectively, and pigeonpeas and mung beans heavily infested with *Callosobruchus maculatus*. Each of the grain species had been previously stored in polypropylene (PP) bags for 6 months to create the heavy infestation situation and then transferred into PICS bags. Each infested bag was replicated four times. The insect counts and gas composition were monitored over a period of four weeks. One hour after the closure of the PICS bags, oxygen level inside the bags had dropped significantly from 21% (v/v) to 10.07% and 8.92% respectively in pigeonpea and mung beans with *C. maculatus* to 13.11% and 8.86 % (v/v), in maize with *P. truncatus* and *S. zeamais*, respectively. Similarly, the carbon dioxide level had increased significantly from 0.00% (v/v) to 9.89% and 10.73%, respectively in pigeonpea and mung beans with *C. maculatus* to 6.63% and 10.98 % (v/v) in maize with *P. truncatus* and *S. zeamais*, respectively. After one week of storage there were no surviving insects in all the PICS bags. The experiments were monitored for three more weeks to check if the eggs and larva could survive to adult stage. After four weeks there were no emerging insects. We conclude that PICS bags can be used to store harvested grain that is infested in the field or accidentally infested grain previously stored in other storage structures. PICS bag is able to stop further development and multiplication of existing and heavy insect infestation.

Keywords: Hermetic storage, maize, mung beans, pigeonpeas, *P. truncatus*, *S. zeamais*, *C. maculatus*

Storage of Common Beans (*Phaseolus vulgaris* L.) in Hermetic Triple-Layer Bag Prevents Losses by *Acanthoscelides obtectus* (F.) (Coleoptera: Bruchidae)

H. D. Affognon^{1*}, A. W. Njoroge¹, D. Baributsa² and L. L. Murdock²

¹International Centre of Insect Physiology and Ecology, P.O. Box 30772-00100, Nairobi, Kenya

²Purdue University, West Lafayette, IN 47907, USA

*Corresponding author; E-mail: haffognon@icipe.org (H. Affognon)

Common beans were stored under ambient conditions for 6 months in Purdue Improved Crop Storage (PICS™) bags or in woven polypropylene (PP) bags. Treatments were artificially infested with Common beans bruchid, *Acanthoscelides obtectus* (PICS1; PP1), while others were not (PICS0; PP0). An additional treatment (PP1Ac) assessed the protective effect of Actellic Super® a commonly used grain protectant. The evolution of oxygen and carbon dioxide concentration in PICS bags was monitored for 6 months. The number of live adults of *A. obtectus* and weight loss were assessed on a monthly basis. The level of oxygen decreased progressively throughout storage and reached 4.71% and 4.61% (v/v) in PICS0 and PICS1, respectively, while carbon dioxide increased to 14.02 and 14.44% (v/v) in PICS0 and PICS1, respectively. PICS bag storage arrested survival of *A. obtectus*, whereas PP bags permitted build-up of its populations. The density of *A. obtectus* was significantly higher in PP1 with 60.9 ± 4.1 insects/125g compared to PP0 (38.1 ± 2.6 insects/125g) and PP1Ac (31.6 ± 3.3 insect/125g). After 6 months of storage, the weight loss of common beans stored in PICS bags was unchanged from the initial level. By contrast, weight losses were $33.6 \pm 2.7\%$, $19.1 \pm 0.3\%$, and $15.4 \pm 0.4\%$, for PP1, PP0 and PP1Ac, respectively. PICS bags represent an effective tool for preserving common beans against *A. obtectus* attack, and their effectiveness is superior to that of Actellic Super® (permethrin (0.3%) + pirimiphos-methyl (1.6%)).

Keywords: Hermetic storage, PICS bag, Polypropylene (PP) bag, Common beans, *Acanthoscelides obtectus*.

Effectiveness of the Triple-Layer Hermetic Bag Against *Prostephanus Truncatus* and *Sitophilus Zeamais* in Three Varieties of Maize.

J P. Anankware^{1*}, K..Afreh –Nuamah¹, D. Obeng-Ofori¹ and A. Adekunle²

¹University of Ghana, P.O. Box LG 56, Legon. Ghana

²Forum for Agricultural Research in Africa (FARA), Ghana.

*E-mail;anankware@yahoo.com

The maize weevil *Sitophilus zeamais* (Mot) and the Larger Grain Borer *Prostephanus truncatus* (Horn) are major pests of stored grains in Ghana. Studies were carried out under laboratory conditions of 32 ± 2 °C and 58-88% r.h. to determine the effectiveness of the triple-layer hermetic bag against the two insect pests species on stored maize. Three storage bags (Triple-layer hermetic bag, Jute and Polypropylene) and three maize varieties (Obatanpa, Abrodenkye and Kamangkpong) widely cultivated in Ghana were used in the study. A factorial experiment was conducted involving 5 kg of each maize variety with moisture content between 12.5-14%. These were stored in the various bags and a destructive sampling of 54 bags (27 bags for each insect species) was done each month for a 6 month storage period. Percentage damage, weight loss, moisture content, mean development periods and insect numbers were determined. Oxygen depletion rate and seed viability were also monitored.

Grain Storage and Insect Pests in Rural Niger

I.B. Baoua¹, L. Amadou², M. Abdourahmane², O. Bakoye², D. Baributsa³ and L.L. Murdock³

¹University of Maradi, Faculty of Agronomy and Environmental Sciences.

BP 465, Maradi, Niger

²Institut National de la Recherche Agronomique du Niger

(INRAN) BP 240, Maradi, Niger

³Department of Entomology, Purdue University,

West Lafayette, IN 47907, USA

Some 1,293 farmers and traders in southern Niger were interviewed to learn about their grain storage practices and any associated major storage pest problems. The key insect pests of stored grain found in 40 localities in Dosso, Maradi, and Zinder regions were identified. We collected 371 grain samples from respondents and stored them in the laboratory for seven months to assess insect development and grain weight loss. The most commonly stored commodities were millet (53%) and sorghum (80%); both typically stored for about 6 months. After seven months of storage in the laboratory, two pests were found in the collected millet samples. These were the rice moth, *Corcyra cephalonica* Stainton, and *Tribolium* spp., and the weight loss was 17.1%. Sorghum samples stored for seven months had *Tribolium castaneum* Herbst, *Sitophilus granarius* L., *Cryptolestes* spp, *Sitotroga cerealella* Oliver, *Trogoderma granarium* Everts, *Rhyzopertha dominica* F. and *C. cephalonica* and exhibited weight loss of 10.1%. Other grains or foodstuff were stored by 2.9 to 24.4% of respondents. Recorded weight losses of collected samples stored for seven months in the laboratory were 15.9% for groundnuts, 12.6% for paddy rice, 7.6% for sesame and 7.4% for maize. Seeds of *Hibiscus sabdariffa* L. and Bambara groundnut were almost totally destroyed by bruchids during storage, mean weight losses being 83.9% and of 61.8% respectively. Most respondents took no measures to control insect pests in their stored grains. Our results show that there are needs and opportunities to use hermetic triple bagging to reduce storage losses and improve food security and nutrition.

PICS Bags for Post-Harvest Storage of Maize Grain in West Africa

I.B. Baoua¹, L. Amadou², O. Bakoye², D. Baributsa³ and L.L. Murdock³

¹University of Maradi, Faculty of Agronomy and Environmental Sciences,
BP 465, Maradi, Niger;

²Institut National de la Recherche Agronomique du Niger
(INRAN) BP 240, Maradi, Niger;

³Department of Entomology, Purdue University,
West Lafayette, IN 47907, USA

Maize is a key food crop in West Africa. Benin, Ghana, Burkina Faso and Nigeria account for at least 85% of the regional production. Storage losses are estimated between 20 - 30%, with insects being a major contributing cause. Triple bagging technology (Purdue Improved Crop Storage - PICS) has been evaluated for maize storage. Thirteen test units were set up in July and August 2012 in 11 localities in Benin, Burkina Faso and Ghana. Each unit consisted of three or four PICS bags of 50 kg capacity and two woven polypropylene control bags. In seven of the localities, the experiment used naturally infested local maize having relatively high levels of infestation with *Prostephanus truncatus* Horn, *Sitophilus zeamais* Motschulsky, 1855 and/or *Rhyzopertha dominica* (F.). Lightly infested maize showing little or no evidence of damage was used in the four remaining sites. After 6.5 months of storage in PICS bags, there was 95 to 100% insect mortality at all sites. No significant increase in seed damage or weight loss were seen in PICS bag. PICS bag inner liners exhibited some perforations when high populations of *P. truncatus* were present but this did not prevent oxygen levels inside the bag from falling; these remained substantially below ambient at about 12% (v/v). Seed viability was well maintained in PICS bags. Aflatoxin tests were carried out on 245 samples, with 44% having levels above 20 ppm in both types of bags. Samples from PICS bag tended to have less aflatoxin than those from ordinary woven bags. PICS bags can be used for maize storage even in areas with high prevalence of *P. truncatus*, but storage of maize should begin immediately after harvest and drying to minimize bag damage that may occur when very high numbers of *P. truncatus* are present.

Evaluation of Hermetic Maize Storage for Smallholder Farmers

D. Bbosa, T. J. Brumm, C. J. Bern and K. A. Rosentrater
Agricultural and Biosystems Engineering, Iowa State University,
Ames, Iowa, 50011
E-mail: dbbosa@iastate.edu

Maize is an important crop for many smallholder farmers in the world. Maize weevils (*Sitophilus zeamais*) cause a significant loss in quality and quantity during maize storage in tropical regions. Hermetic storage of maize has been shown to be effective in controlling maize weevils in laboratory settings. The objective of this research was to test the effectiveness of hermetic storage containers that could be used by smallholder farmers. Six 208-L (55-gallon) steel barrels were filled with 170 kg (375 lb) of maize with initial weevil population of 25 live weevils/kg of maize (11 live weevils/lb). The barrels were placed in a room at 27C (81F) and non-hermetically sealed for three weevil lifecycles of approximately 40 days each. After 120 days, the weevil population increased to an average of 99 live weevils/kg (45 live weevils/lb). Three barrels were then hermetically sealed and equipped with oxygen sensors. After storage for 21 days, the weevil population was zero live weevils/kg in the hermetically sealed barrels (100% mortality) and an average of 114 live weevils/kg (52 live weevils/lb) in the non-hermetically sealed barrels. The means of the oxygen content during storage, and ending number of live weevils per kg of maize, test weight (TW) and moisture content (MC) were significantly different between the hermetic and non-hermetic storage treatments. Broken corn and foreign material (BCFM) and mechanical damage (MD) were not significantly different. Hermetically sealed steel barrels for maize storage can control maize weevils and may be an effective storage option for smallholder farmers.

The Effectiveness of PICS Technology in Rwandan Households

B. Berg
Tubura, One Acre Fund, Rwanda

From February – December 2013, One Acre Fund Rwanda (TUBURA) tested the effectiveness of the PICS hermetically sealed storage bag as a means of 1. reducing post-harvest grain damage, 2. increasing post-harvest storage periods thereby increasing financial profits from grain sales and reducing financial expenditures from grain purchases, and 3. reducing insecticide use, among smallholder farmer households in Rwanda. The bag was tested with 231 smallholder farmers in a randomized control trial in Rwanda's western and eastern regions. All clients in the trial were given the option to purchase PICS bags at a price of 1500 Rwandan Francs. Adopters were split into two groups, with half of those receiving the bag and the other half receiving a refund for their purchase. Clients were visited on a bi-weekly basis to track their household's grain sales and purchases as well as the insect damage to their grains.

The PICS bag proved to be more effective than insecticide and no-treatment as a means of protecting grains against insect damage, with grains stored in PICS, insecticides, and no-treatment having an average of 4.50, 6.76, and 9.51 holes/100 grains respectively. Households that received PICS bags also earned more money for their grain sales from February 2013 – December 2013 with PICS households and non-PICS households selling at an average price of 317.42 FRw and 289.68 per kilo of beans respectively. Based on the findings of this trial, in January 2014 One Acre Fund began commercial sales of PICS bags within the districts of Kayonza, Rwamagana and Gatsibo.

Do Triple Bag Hermetic Storage Control *Prostephanus Truncatus* (Horn) (Coleoptera: Bostrichidae) in Stored Maize in Mozambique?

D. Cugala¹, L. Muchiruarapa¹, and H. Affognon²

¹Faculty of Agronomy and Forest Engineering, EMU, PO Box 257, Maputo, Mozambique

²The International Centre of Insect Physiology and Ecology (*icipe*), Nairobi, Kenya

Prostephanus truncatus is a serious and dominant pest of stored maize in Mozambique. Before the introduction of *P. truncatus* in Mozambique in 1999, weight loss in stored maize in small scale farmers' system was about 10 to 12% and *Sitophilus zeamais* was the most important pest of stored maize. However, the level of losses increased dramatically after the introduction and establishment of *P. truncatus* in Mozambique to 61.5% (about 5 times higher) and a reduction in storage period and availability of food from 10 to 12 months before to 6 months. The shortage of food that occurs annually in Mozambique is mainly due to the weaknesses in storage systems leading to high losses of maize during the storage period due to storage insect pest's infestation and thus contributing to food insecurity in the country. The use of synthetic insecticides has been recommended for the control of *P. truncatus* and other storage insect pests. However, there is little or no use of chemical insecticides in small scale storage systems because of the high cost and hazardous effects on human health and environment. The present study was conducted to assess the effectiveness of triple bag hermetic storage (PICS bag) in controlling *Prostephanus truncatus* in storage in Mozambique. The study was conducted in a completely randomized block design with 6 treatments including T1= Maize + PICS bag + *P. truncatus* + Actellic; T2 = Maize + PICS bag + *P. truncatus*; T3 = Maize + PICS bag; T4 = Maize + normal (PP) bag + *P. truncatus* + Actellic; T5 = Maize + normal (PP) bag + *P. truncatus*; T6 = Maize + normal (PP) bag (control), arranged in 4 replications. *P. truncatus* population density and maize weight loss were estimated monthly from 500 g of maize sample, during 180 days. At the start of the experiment, before infesting bags, the number of insects and the weight loss were zero for all the treatments. At 180 days of storage in all PICS bag treatments, the number of insects was 0.0, 7.0±2.7 and 0.0 in T1, T2 and T3, while the weight loss was 0.0%, 0.3±0.3% and 0.0% respectively. In contrary, at 180 days of storage in the PP bag treatments there was a significant increase in the numbers of insects. The number of insects was 107.3±45.5, 701.8±77.4 and 61.0±36.3 in T4, T5 and T6, with weight loss of 1.4±0.8%, 46.3±18.1% and 4.8±0.0% respectively. These results suggest that the population of *P. truncatus* can be effectively controlled by using the PICS bags. Thus, the use of PICS bags could be recommended for use in the small scale farmer's storage system in the country.

Economic Analysis of Hermetic Maize Storage Technologies and their Impact on Welfare of Farm Households in Kenya

Z. Gitonga

International Maize and Wheat Improvement Center (CIMMYT),
Nairobi, Kenya

Maize is the most important food staple in Eastern and Southern Africa, with a highly seasonal production but relatively constant consumption over the year. Farmers have to store maize to bridge seasons, for food security and to protect against price fluctuations. New hermetic technologies have been developed and are being promoted in Africa for safe storage of grains. However, the technologies need to be subjected to trials and economic analysis. In this study, results of crop loss trials were combined with measures of project worth to determine the benefits (loss abated) of investing in new storage technologies. The loss abated using a one ton metal silo was USD100 in 12 months. These benefits increased with time implying that a farmer would benefit by storing longer. Measures of project worth, the NPV and BCR were used to analyze the attractiveness of investing in the new technologies at a discount rate of 15% and an investment period of 15 years. Sensitivity analysis was done by varying the discount rate and the investment period. Bigger silos of one ton or more were found to be more cost effective for all these scenarios. We also used propensity score matching to evaluate the impact of metal silos on duration of maize storage, loss abatement, cost of storage, and household food security. Metal silo adopters (N = 116) were matched with non-adopting farmers from a representative sample of 1340 households covering the major maize-growing zones in Kenya. The major effect of the metal silos was an almost complete abatement of losses due to insect pests, saving farmers US\$130. Metal silo adopters also spent less on storage insecticides. They also stored their grains longer and the period of inadequate food provision among adopters was reduced by more than a month. We conclude that metal silos are effective in reducing grain losses due to maize-storage insects, and that they have a large impact on the welfare and food security of farm households. Therefore, promoting larger silos would be more cost-effective to the farmer. The initial cost of metal silos is high and therefore policies to increase access to credit, to reduce the cost of sheet metal and to promote collective action can improve their uptake by smallholder farmers.

Keywords: Hermetic technology, metal silos, storage

PICS Bags Reduce Grain Storage Losses of Pulses in Afghanistan

W. Hakimi¹, M. S. Rauf¹, Abdulrahim² and H. Sabiri²

¹Afghan Agricultural Project (AAEP), Herat, Afghanistan.

²Urdukh Research Farm, DAIL Herat, Afghanistan.

Experimental trials were implemented in in four provinces in Afghanistan to assess the performance of PICS bags in storing several crops including mungbean, chickpea, lentil and maize. Grains were stored by farmers in PICS and regular woven bags. After 6 and 18 months of storage, there were significance difference between PICS bags and PP woven bags in protecting grain of these commodities. PICS bags did not have insect presence after 6 and 18 months while PP woven bags had live insects. Grain weight losses varied by crop, locations, and storage methods- were minimal in PICS bags but higher in PP woven bags reaching up to 43%. Germination as well varied by crops, location, and storage methods. Germination reduction were equal or below 5% in PICS bags while in PP woven bags it was reduced by at least 15% and reached 60% for mungbean in Kabul. Mungbean appeared to have the highest weigh loss in all three locations. PICS bags are effective in reducing insect infestation, weight loss and maintain seed viability.

Keywords: Grain storage, PICS bags, Storage pests, Afghanistan

Exploiting the Advantages of a Post-Harvest Dichotomy: Store Wet First Rather Than Dry Immediately for Increased Control of *Sitophilus zeamais* Infestation.

K. E. Ileleji¹, N.K. Addae-Mensah¹ and L. Mason²

¹Dept. of Agricultural and Biological Engineering, Purdue University, 225 South University Street, West Lafayette, IN 47907-2093, USA.

E-mail ileleji@purdue.edu, tel. 765 494 1198, Fax 765 496 1115

²Dept. of Entomology, Purdue University, West Lafayette, IN, USA

Hermetic storage utilizes the natural respiratory activities in grain, insect and fungi metabolisms to modify the atmosphere of an air-tight storage system such that the simultaneous depletion of oxygen and increase of carbon dioxide reaches a level that prevents insect pest and mold growth. The faster oxygen is depleted and CO₂ levels elevated, the better the efficacy of the stored environment to control insect pests and mold. A recent study showed that while it is not favorable to hermetically store high-moisture corn at 21% long-term, the increased rate of CO₂ production by high-moisture corn favored rapid oxygen depletion that increased mortality (100%) and suppressed progeny production of *Sitophilus zeamais* (maize weevil). This poster proposes a strategy of how to utilize both opposing post-harvest goals viz-a-viz, storing high-moisture corn hermetically for a short-period (15-20 days) to eliminate insect pests, rather than immediate drying, after which drying can be done to a safe moisture (13% or less) for long-term storage.

Keywords: Hermetic storage, moisture content, mold growth, *Sitophilus zeamais*, Corn

Consumer Preferences for Maize in Malawi: A Stated Preferences Approach with Attribute Non-Attendance to Evaluate Impact of Insect Damage, Variety, and Mold

**M. Jones¹, C. Alexander², J. Ricker-Gilbert², N. Olynk²,
and J. Lowenberg-DeBoer³**

¹Food and Resource Economics Department, University of Florida,
Gainesville, Florida, USA

²Department of Agricultural Economics, Purdue University,
West Lafayette, IN, USA Email: cealexan@purdue.edu

³International Programs in Agriculture,
Purdue University, West Lafayette, IN, USA

For marketing maize producers, economic losses from storage pests cause both dry weight loss and price discounts for damaged grain. However, price discounts are absent from the East and Southern African maize literature. We use a choice experiment (CE) with physical samples of maize to estimate preferences for local vs. hybrid variety, insect damage, and mold damage among Malawian maize traders. Results with mixed logit and latent class models demonstrate severe discounting for insect damage, and these discounts increase with traders' intention to store for longer periods of time. The Equality Constrained Latent Class (ECLC) method is used to identify and correct for price non-attendance bias, a common problem in stated preference research. Results are compared with a smaller scale contingent valuation method which yields lower, yet still significant price discounts for insect damage. The value of preventing insect damage in long-term maize storage is found to be quite high in Malawi, signaling that effective storage technologies may provide significant benefits to marketing producers.

How Do Storage Losses and Price Seasonality Affect Food Security in sub-Saharan Africa? Evidence from Maize Farmers in Benin

D. Kadjo¹, J. Ricker-Gilbert¹, C. Alexander¹, A. Tahirou², M. Nasser Baco³

¹Department of Agricultural Economics, Purdue University,
West Lafayette, IN, USA Email: jricker@purdue.edu

²International Institute of Tropical Agriculture, Ibadan, Nigeria

³Department of Agronomy, University of Parakou, Parakou, Benin

This study uses data from 360 farm households in Benin, West Africa, to estimate how storage technologies, storage losses from insects, and large intra-seasonal price increases affect smallholder farmers' decisions to store maize. We find that access to storage chemicals increases the average quantity stored by 196 kilograms (10% more) with results approaching statistical significance. This extra stored grain translates to an income gain of US \$44 on average. Farmers who use woven plastic bags store 293 kilograms less grain on average (15% less), likely because these bags are used to market maize in addition to storage. Had this maize been stored at harvest rather than sold, the household would have gained US \$73.50 in income on average. Results from our study also suggest that farmers who intend to sell maize during the lean season rely on large intra-seasonal price increases to compensate for storage losses. In contrast, subsistence farmers store less at harvest to avoid storage losses, which may undermine their food security in the lean season. Expected post-harvest storage losses appear to deter farmers with low physical and financial assets from storing grain. These findings highlight the need to develop and make effective storage technologies accessible to smallholder farmers in sub-Saharan Africa.

**Impact of Triple Bagging Technology for Managing
Prostephanus truncatus (Coleoptera: Bostrichidae)
in Stored Maize**

T. Kasambala-Donga¹, Y. Tembo¹, G.K.C. Nyirenda¹,
D. Baributsa² and L.L. Murdock².

Email: trustkasambala@yahoo.co.uk

¹Department of Crop and Soil Sciences, Bunda College Campus, Lilongwe
University of Agriculture and Natural Resources, P.O. Box 219, Lilongwe

²Department of Entomology, Purdue University,
West Lafayette, IN 47907, USA

In order to determine the ability of the larger grain borer, *Prostephanus truncatus* (Coleoptera: Bostrichidae) to hole through the tripple bags of the Purdue Improved Crop Storage (PICS) bag using in small scale hermetic storage of grains, an experiment was set on 23rd May 2013 in the Entomology Laboratory at Bunda College. **Heavily infested maize was thoroughly mixed before weighing 20kg for the experiment. Maize that was treated with** insecticides or freshly harvested grain was not mixed with the experimental grain. The treatments (maize in PICS bags and maize in polypropylen PP sacs) were replicated three times. A total of 12 bags (8 PICS bags and 4 PP bags) were used. Data was collected 2 times, at 30 and 60 days after storage. Results indicate that the PICS bags were effective in controlling *P. truncatus* and that *P. truncatus* could not hole through the PICS bags from within.

Triple bag Technology for Bambara Nuts and Hibiscus seeds in Niger: A Profitable Investment

B. Moussa, S. Boureima, M. M. Madougou, D. Baributsa, and
J. Lowenberg-DeBoer

The Purdue Improved Cowpea Storage Project (PICS) has intervened in almost 31,000 villages in 10 countries in West and Central Africa with the aim of focusing on cowpea storage using the triple bag technology. While the technology was initially introduced for cowpea grains, the earlier studies have observed that farmers experimented with it for crops other than cowpea. This is in part what motivated the second phase of the project (PICS2) in order to investigate the potential use of the triple bag technology for crops other than cowpea. Bambara nuts and hibiscus seeds are two products with important economic potential, especially for women, which have been targeted in Niger because of their high infestation rate and the anticipation of the farmers in using the triple bag method for storing them. Thus, interviews were conducted in July 2013 in the main production areas for these two products in order to evaluate the profitability of using the triple bag technology as a storage method. About 160 farmers producing both Bambara nuts and hibiscus. In addition, 50 traders were interviewed on their storage practices in Dosso, Maradi, and Zinder regions. Information on price seasonality was also collected to perform the economic analyses on profitability. Preliminary result has showed that triple technology is already being used by farmers for both products. However, because no deliberate extension program was conducted on triple bag technology as storage method for Bambara nuts and Hibiscus seeds, the rate of use is relatively low compared to cowpea for example. For Bambara nuts for example, for the 2012 harvest farmers stored with triple bag 47 %, 8 % and only 4 % of their total quantity stored in Dosso, Zinder and Maradi region respectively. For Hibiscus the quantity stored with the technology are even smaller, 4 %, 2 % , 2 % for Dosso, Maradi and Zinder respectively. For Cowpea, for the same harvest year 2012, up to 40 % of the total was stored with triple bag method in Maradi region while the percentages are 38 % and 19 % for Dosso and Zinder respectively. Price information collected has showed a relatively high variation over time that allows profitability of Bambara nuts and hibiscus storage with triple bag compared to traditional method. Preliminary results indicate net returns of above 90 % and 100 % for 9 months storage for Hibiscus and Bambara nuts respectively.

Evaluation of Triple Layer Hermetic Storage Bag (PICS) against *Prostephanus truncatus* and *Sitophilus zeamais*

K. Mutambuki^{1*}, H. D. Affognon² and D. Baributsa³.

¹Kenya Agricultural Research Institute, National Agricultural Research Laboratory, Nairobi, Kenya

²International Centre of Insect Physiology and Ecology, Nairobi, Kenya

³Department of Entomology, Purdue University, West Lafayette, IN 47907, USA

*Corresponding author: E-mail: mutambukikimo@yahoo.com

The use of hermetically-sealed containers that are sufficiently airtight such as metal concrete silos and some plastic bags has gained importance as an alternative to other methods of storage for the protection of various commodities from insects and moulds. A study simulating farmer storage practices was conducted to evaluate the triple layer Purdue Improved Cowpea Storage (PICS) airtight bags against two major storage insects. Two sets each of PICS, jute and polypropylene bags were filled with 45kg maize grain. Each set was replicated four times. In one set of PICS bags 50 insects each of the larger grain borer (LGB) *P.truncatus* and *S.zeamais* were introduced. One set of jute and polypropylene woven bags were treated with a cocktail of permethrin and pirimiphos methyl. The remaining sets formed the controls. After taking a sample for baseline grain damage analysis, the PICS bags were tightly tied from inner to outer layers. Together with the jute and polypropylene bags, they were placed on pallets laid out in a barn for subsequent gas and grain damage analysis at bi-monthly intervals for up to six months. Results of mean weight of dust, live insects and grain damage over the six month trial period showed significant differences between PICS and the other treatments especially at the 16th and 24th week but more pronounced at the end of the trial period. PICS bags performed better than all the other treatments.

Gas analysis in the PICS bags followed the expected trend with oxygen levels falling sharply below 10% and carbon dioxide increasing to almost 10% up to 12 weeks hence resulting in death of infesting insects. After 16 weeks, increase in oxygen levels may be attributed to perforation of the bags by the LGB. These results demonstrate the potential of PICS bags in protecting stored maize in LGB infested areas.

Keywords: PICS bags, *P. truncatus*, *S. zeamais*, farmer storage simulation

Storage of Mung Bean (*Vigna radiata* [L.] Wilczek) and Pigeonpea Grains (*Cajanus cajan* [L.] Millsp) in Purdue Improved Crop Storage (PICS™) Bags Stops Losses Caused by *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae)

C. M. Mutungi^{1,2}, H. D. Affognon^{1*}, A. W. Njoroge¹, D. Baributsa³
and L. Murdock³

¹ International Centre of Insect Physiology and Ecology,
P.O. Box 30772-00100, Nairobi, Kenya

² Department of Dairy and Food Science and Technology Egerton University, P.O. Box
536-20115, Egerton, Kenya

³ Purdue University, West Lafayette, IN 47907, USA

*Corresponding author; E-mail: haffognon@icipe.org (H. Affognon)

Dry mung bean and pigeonpea grains that had sustained some insect damage but fumigated before the start of the experiment were stored in PICS™ bags or woven polypropylene (PP) bags for 6 months. Some of the bags were artificially infested with cowpea bruchid *Callosobruchus maculatus* (F.) (PICS1, PP1) while others were not (PICS0, PP0). In an additional trial, PP bags containing the grains were treated with Actellic Super® dust before being artificially infested (PP1Ac). Live adult *C. maculatus* counts and weight loss were determined on a monthly basis. Storage in PICS bags halted multiplication of *C. maculatus*, and the initial weight loss of grains (0.6%) did not change. Conversely heavy insect build-up in the PP bags resulted in weight losses exceeding 12.5% in both mung beans and pigeonpeas. Our results indicate that PICS bags are an effective tool for preserving mung beans and pigeonpeas against *C. maculatus* attack, and their performance is superior to that of Actellic Super® dust.

Keywords: Hermetic storage, Mung beans, pigeonpeas, *Callosobruchus maculatus*, Actellic Super® dust

The Groundnut (*Arachis hypogea* L.) Storage Status in the Cowpea Production and PICS Dissemination Areas of Senegal.

I. Sarr¹, D. Baributsa² and I. Baoua³

¹Institut Sénégalais de Recherches Agricoles BP: 53 Bambey - Sénégal

²Purdue University, Purdue Improved Crop Storage - USA

³Institut National de Recherches Agronomiques– Niger

In Senegal, groundnut is the most important cash and food security legume crop. Post-harvest storage loss is significant due insect attacks. A rapid assessment of groundnut storage was conducted in 2012 among 144 farmers in Louga region in northern Senegal where cowpea is mostly grown and the Purdue Improved Crop Storage (PICS) technology was disseminated. The main storage methods used by farmers were: metal drums (59%), ordinary woven polyethylene bags (18%) and PICS bags (23%). Samples collected among farmers showed that the main pests were *Caryedon seratus* and *Tribolium castaneum*. There were low infestations and insect damages among the three storage methods. However, the germination was higher in both PICS bags (75.4%) and metal drums (74.7%) compared with insecticide treated groundnuts (61.4%). A follow-up laboratory study comparing PICS bags and commonly used insecticides to store shelled and unshelled groundnuts was implemented. After nine months of storage, unlike in control, no infestation of *C. seratus* in shelled groundnuts was observed in PICS bags and insecticide treatments. However, in unshelled groundnuts, there were higher infestations in control (71 insects/100grains) and insecticide treated (36 insects per 100grains) when compared to PICS bags (0 insect per 100grains). The data show that farmers are using the technology to store groundnuts and it is effective in controlling the major pests of groundnuts.

Keywords: groundnut, hermetic storage, PICS bags, Senegal.

Purdue Improved Crop Storage (PICS) Bags for Safe Storage of Groundnuts

H. Sudini¹, G.V. Ranga Rao¹, C.L.L. Gowda¹, R. Chandrika¹, V. Margam², A. Rathore¹, and L.L. Murdock²

¹International Crops Research Institute for the Semi-Arid Tropics,
Patancheru, India

E-mail h.sudini@cgiar.org

²Dept. of Entomology, Purdue University, West Lafayette, IN, USA

Groundnut seeds are prone to quality deterioration and damage due to improper storage. Hermetic storage of pods offers a novel, sustainable and ecologically safe alternative over traditional methods. In this paper, we demonstrate the efficacy of triple-layer “Purdue Improved Crop Storage (PICS)” bags, (that comprises of two inner high density polyethylene bags and one outer woven polypropylene bag), for protecting pods from quality deterioration, damage by bruchids (*Caryedon serratus*) and aflatoxin contamination (*Aspergillus flavus*). Custom made triple-layer bags were used and pods (of cv ICGV 91114) were placed @ 2 kg/bag. **Over four months of storage under ambient conditions, triple-layer bags supported retention of seed weight, germinability and oil content significantly better than cloth bags. Further, under both natural and artificial infestations with *A. flavus*, seed aflatoxins levels were lower in PICS bags compared to cloth bags. Toxin accumulation in PICS bags deliberately infested with bruchids and *A. flavus* was less compared to cloth bags under similar conditions.** Bruchid damage to pods was less in PICS bags versus cloth bags in all cases. Our results suggest the superiority of triple-layer PICS bags over cloth bags in protecting seed viability, seed weight and oil content of peanut while safeguarding the peanuts from bruchids and retarding toxin accumulation.

Is Flint Corn Naturally Resistant to *Sitophilus zeamais* Infestation?

R. Suleiman, D. Williams, A. Nissen, C. J. Bern, K. A. Rosentrater*
Department of Agricultural and Biosystems Engineering
Iowa State University

*Corresponding author email: karosent@iastate.edu,
other authors email: rashid@iastate.edu, denwills@iastate.edu,
alnissen@iastate.edu and cjbern@iastate.edu

Sitophilus zeamais is one of the most destructive pests of maize stored in tropical and subtropical regions. This study determined the resistance of flint corn and dent corn to infestation by *Sitophilus zeamais* (Motschulsky), the maize weevil. Improved King Philip hybrid flint corn and Fontanelle 6T-510 hybrid dent corn were used. Two temperature conditions (10 & 27°C) and two storage times (15 & 30 days) were used. Results showed that flint corn was more resistant to insect damage than dent corn at 27 °C and 30 day storage time. After 30 days storage time and 27 °C death rate was significantly higher in flint corn ($R^2=0.945$) compared to dent corn ($R^2=0.634$). Damaged seed was 10% higher in dent corn than in flint corn at 27 °C and 30 days. Both dent and flint corn are extensively cultivated in developing countries. It appears that use of flint corn may be one promising solution to reducing corn damage infestation problems in tropics and developing countries, but more research is needed.

Impact of Grain Moisture on Aflatoxin and Seed Germination under Hermetic Conditions

C. Woloshuk¹, S.B. Williams², and D. Baributsa²

¹Dept. of Life Sciences, Purdue University, West Lafayette, IN, USA

²Dept. of Entomology, Purdue University, West Lafayette, IN, USA

Insects and fungi are a major challenge for storing grain, especially in regions of the world where farmers are without sufficient drying and storage capacity. In several African countries, the Purdue Improved Crop Storage (PICS) bag system has proven to be a low-cost and effective means of preventing damage caused by storage insects. PICS bags are nearly impervious to gas, thus biological respiration within the bags causes the buildup of carbon dioxide and a reduction of oxygen, which is inhibitory to the growth of the insects. The goal of the current research is to determine the efficacy of the PICS system towards reducing the risks associated with fungal growth and mycotoxin accumulation, which is important for farmers in the humid tropics. In a pilot experiment, PICS bags containing 2.5 kg of maize conditioned at 12, 15, 18 and 21 % moisture were stored at 26 °C. To follow potential fungal growth, each bag was inoculated with 50 g of maize colonized by a fluorescent-marked strain of *Aspergillus flavus*. After one and two months of storage, we assessed oxygen/carbon dioxide levels, fungal growth, aflatoxin, moisture content, and kernel germination. At both time points, there was no evidence of growth of *A. flavus* or other storage fungi within the PICS bags, and no accumulation of aflatoxin B1 was detected. The moisture content of the maize in the PICS bags also remained nearly constant over the 2-month experiment. In contrast, maize (18 and 21 %) stored in mesh bags under the same conditions exhibited visible molding and aflatoxin B1 accumulation near 100 ppb. The moisture content of grain in the mesh bags also equilibrated with conditions in the storage chamber. These results indicate that PICS bags can prevent fungal growth and aflatoxin accumulation as well as prevent external environmental conditions from affecting grain moisture.