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Side by side comparison of GrainPro and PICS bags for postharvest preservation of cowpea grain in Niger

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ABSTRACT

When cowpea bruchid-infested cowpea grain was stored for four-plus months in Purdue Improved Cowpea Storage (PICS™) bags or in commercially-available GrainPro SuperGrain™ bags, preservation of the grain was equally good in both types of bags. In both bag types oxygen (O_2) levels dropped rapidly during the first 24 h after closure, eventually reaching levels of 1–3 percent by volume (v/v). With both types of bag there was an initial rise in temperature during the first 24 h, followed by a decline, in time reaching ambient. Over the four-plus months of the experiment damage levels did not significantly increase in either type of bag while control grain kept in a conventional woven plastic bag suffered severe damage. Most of the insects found in both GrainPro and PICS bags at the end of the experiment were dead. The single layer SuperGrain™ bags showed more bruchid holes than did triple-layer PICS bags, which had no holes penetrating through both of the inner high density polyethylene (HDPE) layers, meaning that an intact O_2 barrier remained in place even after the inner HDPE layer was holed. Farmers who wish to store their cowpea grain with either technology can choose between the two types of bags, taking into account price, availability and durability.

1. Introduction

In West and Central Africa, cowpea (*Vigna unguiculata* Walp) production was 4.6 million tons in 2010 (FAO-STAT). Cowpea is a key source of food for rural families in the region, who also obtain cash income when they sell their crop. A well-established and ancient trading route brings cowpea from the drier areas of the region to the more populous urban centers on the coast. Cowpea grain is infested by insects in the field as well as during storage after harvest. Grain coming from the field is already infested with bruchids, either by cowpea weevil, *Callosobruchus maculatus* (Fabricius) or another bruchid, *Bruchidius atrolineatus* (Pic). *Bruchidius atrolineatus* adults do not reproduce in storage – they leave the store soon after they emerge as adults. By contrast, each emerging female *C. maculatus* quickly finds a mate and if abundant food is available, produces about 100 offspring. After three or four generations, each of which require only about a month, losses are severe (Caswell, 1961; Prevett, 1961; Alzouma, 1987; Germain et al., 1987).

Over the last five years in the Sahel region, postharvest storage of cowpea to suppress losses to bruchids has improved considerably thanks to the extension of a hermetic triple bagging technology in the form of Purdue Improved Cowpea Storage (PICS™) bags (Baributsa et al., 2010a). A PICS bag consists of one woven polypropylene bag surrounding two layers of high density polyethylene (HDPE), each 80 μ thick. This composite bag costs about 2USD on local markets. PICS bags are effective in stopping bruchid population growth and thus prevent loss of grain (Baoua et al., 2012). The protective mode of action of PICS bags has been described (Murdock et al., 2012). Bruchids are aerobic organisms, each insect requiring about 8.5 ml of pure oxygen (O_2) as it passes from the egg stage to the adult emerging from the seed. When infested grain is sealed in PICS bags the insects living in grain draw down the O_2 levels in the substantially airtight bags thanks to their high consumption of O_2; O_2 levels often drop into the range of 2–5 percent (v/v) or lower – such levels have been measured in PICS bags kept in village stores in Niger. Carbon dioxide (CO_2) levels rise concomitantly. The insects, with subnormal levels of O_2 available to them, cease growing, developing and reproducing. Population growth ceases, preventing substantial loss of the grain.

An alternative to PICS bags is produced by GrainPro™ Company Inc. GrainPro has since 1990 sold sealed containers for grain storage including Cocoon™ which can accommodate up to 300 tons of seeds. This technology has proven effective for storage of wheat in Pakistan attacked by *Tribolium castaneum*, *Rhyzopertha dominica* and *Sitophilus oryzae* (Ane et al., 2011). The Cocoon™ is also used for storing

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rice, corn, coffee, cocoa, groundnuts, sorghum, beans and spices in India, Indonesia, Costa Rica, Ghana, Rwanda, Sri Lanka, Philippines and Pakistan (Rickman and Aquino, 2004; Villers, 2006; Villers et al., 2008; Jonfia-Essien et al., 2010). The SuperGrain™ bag is a portable bag that can contain from 10 up to 1000 kg. It consists of a single layer of 78 μ plastic film made of 2 polyethylene films between which is sandwiched a plastic layer that is highly impermeable to O_2 (http://www.grainpro.com/fr/grainpro-supergrainbag.php). GrainPro containers are being popularized in Afghanistan for wheat storage, for corn and coffee storage in Guatemala and Zambia (GrainPro, Inc., 2010) and for rice conservation in Vietnam (Ben et al., 2009). Tests of their bag were conducted in Niger during 2010 and it was reported that the use of SuperGrain bag permits margins of 76% on cowpea, 528% on Voandzou and 110% for the storage of seeds of *Hibiscus sabdariffa*. The GrainPro technology is already available in Mali, Burkina Faso, Ghana and Niger (http://www.grainpro.com/pdf/GP%20Newsletter_May_2011.pdf). Comparable return data for PICS bags and cowpea was presented by Baributsa et al. (2010b), which showed increases in storage profits in various Malian locations ranging from 59% to 125%.

This present study was undertaken to compare the performance of PICS bags to that of SuperGrain bags available on the West African market. We sought to obtain information useful to those individual farmers and traders who wish to store their cowpea grain so that they could make informed decisions about the best containers for their needs and budgets.

2. Material and methods

Experiments were carried out at the INRAN entomology laboratory in Maradi, Niger. GrainPro bags model GPSB II Z (72 × 100) were purchased from a commercial vendor (http://www.grainpro.com/grainpro-supergrainbag.php). The PICS 50 kg triple-bags were manufactured by Lela Agro (Kano, Nigeria).

Four hundred kilograms of cowpea grain was purchased from the local market. This grain was already infested with cowpea bruchids; the grain was mixed thoroughly so that all replicate samples started with the same initial infestation.

SuperGrain and PICS bags, in four replicates, were each filled with 50 kg of the infested grain. A small quantity of the infested grain was stored in a woven plastic bag as an unprotected control. Samples of grain were taken from each bag at the beginning of the experiment to assess the initial infestation. The following parameters were recorded for each 100 seed sample: number of grains bearing eggs, number containing living adults and larvae of *C. maculatus*, total number of *C. maculatus* emergence holes and weight of 100 grains.

Data loggers, model EL-USB-2 (Lascar, Whiteparish, Wiltshire, Great Britain) were placed in each bag to record temperature and relative humidity over the course of the experiment. All bags were kept in the laboratory storeroom in Maradi for four months and one week – from early January to mid-May. This time interval was chosen because it represents a typical storage time used by farmers until the grain is consumed or sold. It is also enough time to allow at least four generations of cowpea bruchid to develop, which would cause severe damage unless the storage method stopped population expansion. At the end of this period the bags were opened and insect numbers and grain damage assessed.

During the experiment O_2 and CO_2 levels were monitored using a Mocon PAC Check Model 325 Headspace analyzer (Mocon, Minneapolis, MN, USA) fitted with a 20-gauge hypodermic needle for sampling through rubber septa or through storage bag walls. We sealed punctures in bag walls with patches of electrician's tape.

T-tests were performed to compare temperature, humidity, O_2 and CO_2 levels for PICS bags and SuperGrain bags treatments. Analysis of Variance (ANOVA) followed by Least Significant Difference (LSD) tests was used to compare parameters related to infestations and damage per treatments. The statistical analysis was done with SPSS software (Statistical Package for the Social Sciences), produced by IBM SPSS, Inc. in Chicago, Illinois.

3. Results

The experiment was conducted at the INRAN Maradi entomology laboratory at uncontrolled ambient temperature, which ranged from 25 to 35 °C. Bags were filled with infested grain and sealed on 4th January, 2011; they were opened on 11th May 2011, after 127 days of storage.

Temperature: Internal temperatures and changes in internal temperatures over time did not differ between the bags (Fig. 1A). In both types of bags the internal temperature rose by a few degrees during the first 12 h, then began to gradually fall toward ambient. The mean temperature in PICS bags at two hours after bag closure was 27.7 ± 0.2 °C while it was 27.9 ± 0.3 °C in the SuperGrain bags ($t = -0.69$; $df = 6$; $P = 0.57$). Four hours after closing the bags temperatures reached 31.5 ± 0.5 °C in PICS bags and 32.0 ± 0.6 °C in the SuperGrain bags ($t = -1.43$; $df = 6$; $P = 0.20$). Six hours after closure the temperatures were 31.5 ± 0.2 °C in the PICS bags and 32.0 ± 0.3 °C in the SuperGrain bags ($t = -1.46$; $df = 6$; $P = 0.19$) (Fig. 1). The temperature remained similar in both bag types 20 h after closing the bags, with 29.4 ± 0.1 °C in PICS bags and 29.20 ± 0.2 °C in SuperGrain bags ($t = 0.87$; $df = 6$; $P = 0.42$); at 70 h after bag closure the mean temperatures were 24.0 ± 0.1 °C in PICS bags and 24.1 ± 0.1 °C in SuperGrain bags ($t = -0.32$; $df = 6$; $P = 0.76$); at 100 h the respective values were 22.6 ± 0.1 °C in the PICS bags and 22.8 ± 0.1 °C in SuperGrain bags ($t = -1.13$; $df = 6$; $P = 0.30$). At 140 h the mean was 22.3 ± 0.1 °C in the PICS and SuperGrain bags ($t = -0.31$; $df = 6$; $P = 0.77$).

Relative humidity (RH) over time was similar in both types of bags (Fig. 1B). Percent RH rose slightly in both types of bags after

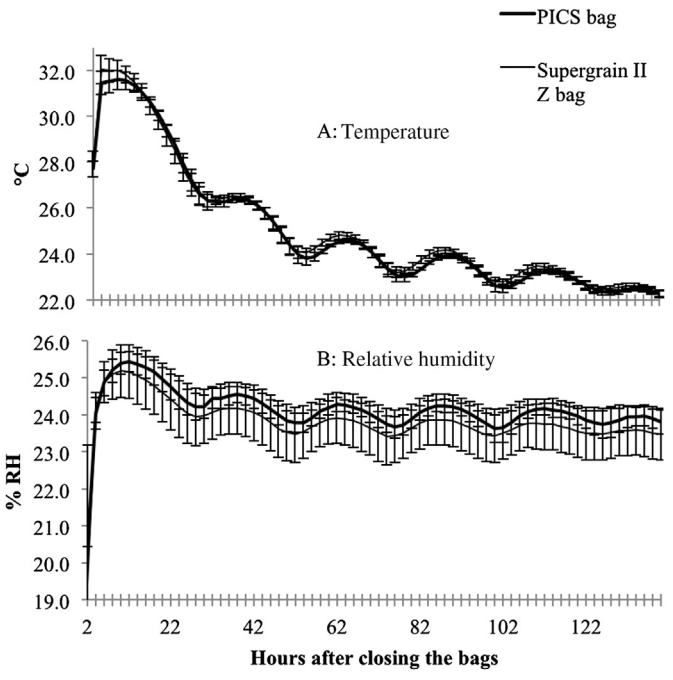

Fig. 1. Variation of temperature (A) and relative humidity (B) in PICS and SuperGrain II Z bags filled with naturally infested cowpea. Waviness in the recorded temperatures and humidities reflects variation in the uncontrolled ambient temperatures in the room in which the bags were kept.