Journal of Stored Products Research 72 (2017) 138–142

Contents lists available at ScienceDirect

Journal of Stored Products Research

journal homepage: www.elsevier.com/locate/jspr

Sorghum seed storage in Purdue Improved Crop Storage (PICS) bags and improvised containers

Scott B. Williams*, Larry L. Murdock, Dieudonne Baributsa

Department of Entomology, Purdue University, 901 W. State Street, West Lafayette, IN 47907, United States

ARTICLE INFO

Article history:
Received 25 August 2016
Received in revised form
8 April 2017
Accepted 10 April 2017

Keywords:
Sorghum seed
Hermetic storage
PICS
Moisture
Oxygen
Germination

ABSTRACT

Seed storage is a major challenge for smallholder farmers in developing nations. Purdue Improved Crop Storage (PICS) bags effectively control the postharvest insect pests of cowpea and other crops. Farmers, encouraged by this success, have begun to expand the use of PICS bags for storing other crops. Little is known about how sorghum seed, one of these important crops, fares when stored under hermetic conditions. Accordingly, we stored sorghum seed for six months in either airtight containers (PICS bags or sealed plastic bottles) or open ones (woven polypropylene bags and open plastic bottles). Overall, sorghum seed stored in PICS bags and in sealed plastic bottles maintained its initial moisture level, germination rate and seed weight. Porous polypropylene bags and open plastic bottles lost moisture over six months. We conclude that sorghum seed can be safely stored in hermetic containers without any loss of quality for extended periods of time.

1. Introduction

Sorghum (*Sorghum bicolor*), native to Africa where more than 36% of the global supply is produced (FAOSTAT, 2015), is an important crop worldwide. Sorghum produces a small, pearl-like grain that ranges in color from white to red to brown and that typically weighs around 25–30 mg. Much of the recent increase in world sorghum production has been for animal feed, though it still remains a staple food source for many dry and semi-arid regions (Curtis, 1967).

Smallholder farmers typically store sorghum seed in small quantities, either threshed or unthreshed (Sorghum and Millets-FAO, 1995). Losses during storage are caused by a combination of biotic (insects and molds) and physical forces. Insects and molds can reduce seed weight and can destroy the nutritional quality of the seed. Aside from such organisms, sorghum grain stored in sealed, airtight containers has been observed to decline in quality under high temperature and humidity (Sorghum and Millets-FAO, 1995).

Options to control pest insects in developing nations are limited. Synthetic pesticides are expensive and hard to obtain (Jones et al., 2011; Njoroge et al., 2014). Even if applied appropriately, several applications may be needed to prevent damage. Repeated treatments are not only more expensive and laborious, they also increase the chance for human or environmental toxicity (Meikle et al., 2002; Addo et al., 2002). Synthetic pesticides are not a preferred option for most farmers seeking to control grain pests.

Hermetic storage for grain has been used for pest control in one form or another since ancient times (De Lima, 1990; Njoroge et al., 2014). More recently, this storage method has increased in popularity thanks in part to the dissemination of Purdue Improved Crop Storage (PICS) bags throughout Africa. The PICS bag consists of two polyethylene liners and one outer layer of woven polypropylene. Together, the three layers severely restricts oxygen flow into the grain from the surrounding airspace. Respiration of insects, grain and other organisms changes the composition of the air within the bag, decreasing oxygen levels and increasing carbon dioxide. These conditions are inhospitable for most grain pests. Population growth is arrested and many of the insects die (Baoua et al., 2012). PICS bags have become widely available throughout West Africa, where almost 50% of cowpea kept on farm is stored in some sort of hermetic container (Baributsa, 2014; Moussa et al., 2014; Ibro et al., 2014). Farmers, noting the success of PICS with cowpea, have already begun to store other crops such as maize and sorghum, in PICS bags.

Only a few studies have investigated the storage of sorghum

* Corresponding author.
E-mail addresses: willi324@purdue.edu (S.B. Williams), murdockl@purdue.edu (L.L. Murdock), dbaribut@purdue.edu (D. Baributsa).

http://dx.doi.org/10.1016/j.jspr.2017.04.004
0022-474X/

seed under hermetic conditions (Ellis and Hong, 2007). With farmers already storing sorghum in PICS bags, it is essential that we collect evidence to determine if sorghum seed can be safely stored under these conditions. This would lay the scientific foundation for encouraging further adoption and use of the technology for seed storage. Accordingly, we investigated the performance of sealed hermetic bags as well as plastic bottles for storing sorghum seed to determine if these containers maintain seed quality as well or better than unsealed containers. Since our focus was mainly on seed viability and germination, care was taken to ensure that no insects were present in the sorghum grain kept in the test containers.

2. Methods

2.1. Trial set-up

Red sorghum seed (Channel Seed #A1005963) was purchased from Channel Seed, (Kentland, IN) and stored for a period of 6 months between September 2014 and March 2015. This seed had been frozen for five days prior to setting up the experiment to kill any insects present and then stored in hermetically-sealed buckets until used. A total of 200 kg of sorghum seed was stored as 20 kg units in ten storage bags, each with a 50 kg storage capacity. Five bags were the PICS, hermetically-sealed triple bag and the remaining five bags consisted of the relatively-porous woven polypropylene layer of the PICS bag. These woven bags served as the control group for the trial. Each of the ten bags was filled with 20 kg of sorghum seed and a data logger (EL-USB-2, Lascar, Erie, PA, United States) was placed in the center of the seed mass to continuously record temperature and relative humidity (R.H.) in the grain. Once filled, each bag was sealed and then held in storage in the laboratory under ambient temperature and relative humidity for the six month duration of the study. In addition to the bags, ten, 2-L plastic bottles were filled with sorghum seed. Five bottles were sealed by twisting the cap tightly to create an airtight environment. Five additional bottles had holes drilled in the caps to give access to air and served as the control group.

2.2. Sample collection

Seed for analysis was collected from the storage bags every two months during the trial period. At each data collection interval, twenty, 30 mL samples of seed were removed using a standard probe (600 mL per bag sample). All samples from a specific bag were pooled together in a glass Mason jar and stored in a freezer until needed. Data from the plastic bottles was collected only at the end of the six month study period. The following data were collected as described below: moisture content, germination rate, and dry weight.

2.3. Oxygen levels

Internal oxygen readings were measured using an Oxysense 5250i oxygen reader (Oxysense, Dallas, TX). The Oxysense measures oxygen by exposing the surface of a yellow fluorescent dot to ultraviolet light. This light causes the pigment of the dot to emit light of a different wavelength. The intensity of the fluorescent light corresponds to the level of oxygen in the air surrounding the oxydot. Two oxydots were used in each sealed PICS bag and one dot for each unsealed bag. Oxydots were glued to a glass petri dish. One petri dish was attached with tape to the innermost plastic liner and a second attached to the outer plastic liner. This second dish was added to better-understand the oxygen dynamics of the inter-liner space. A small window was cut out of the woven mesh layer of each PICS bag so that the Oxydots were visible. Petri dishes were attached directly to the woven mesh layer in control bags, with only a small hole large enough to take readings.

Oxydots were also placed on the inner walls of the plastic bottles used in the alternative trial. One dot was placed 8 cm from the top of the bottle while the second dot was placed 8 cm from the bottom. This set-up was used for all bottles.

Oxygen data was collected at regular intervals throughout the treatment period. Frequent, hourly recordings were taken at the beginning of the trial, with the interval gradually increasing to a week between readings. Data was collected throughout the entire six month trial period.

2.4. Moisture content

Grain moisture was measured using a Dickie-John mini GAC® Plus Grain Moisture tester (Dickey-John Co., Auburn, IL) following the manufacturer's instructions. After a blank reading without grain, the instrument was filled with sorghum seed. Any excess at the top was removed and then measurements taken. Moisture content of the grain sample was recorded as a percentage of the total grain mass.

2.5. Germination rate

Two samples of 100 seeds were removed from each bag. Seeds were bathed in a 10% bleach solution for 2 min and then rinsed three times with water. Each sample was wrapped with wet paper towels and stored in a dark drawer for one week. At this time the samples were removed and the number of seeds with at least part of the radicle breaking through the seed coat was counted as germinated. Data was recorded as the percentage of the number of successfully-germinated seeds out of the total number of seeds sampled.

2.6. Dry seed weight

Sorghum seed were measured out into four samples of 10 mL volume. The number of seeds per sample was counted and checked for signs of physical damage. Seeds were placed in a drying oven at 60 °C for 5 days and then removed. After cooling, each sample was weighed independently on a digital scale to the nearest $1/100^{th}$ of a gram.

2.7. Analysis

The relationship between environmental temperature and humidity and the internal bag conditions for both treatment groups were compared using Pearson's correlation. Differences in average oxygen levels between treatments were compared using paired t-tests. The effect of treatment on measurements of quality (grain moisture, seed weight, germination) was compared using a student's t-test. An additional, two-factor Analysis of Variance was used for the bag trials in order to determine the influence of time on our observations. Significant values were reported at the $\alpha = 0.05$ level unless noted otherwise.

3. Results

3.1. Absence of insects

Over the six month period, no insects were observed in the storage containers or inside the seeds removed at each sampling period. Neither were there signs of feeding damage to seeds observed in either treatment group, confirming that there was no contamination by insects during the study.