KOPERNIK PROJECT REPORT – EXPERIMENTATION PROJECTS

INCREASING FARMER FOOD SECURITY AND INCOMES: GRAIN STORAGE SOLUTIONS

PHASE TWO

CONTEXT

Sorghum, a type of cereal grain, was first introduced in Likotuden, East Flores by a local farmer approximately two years ago. Other farmers in the area soon followed to adopt sorghum as it does not require much water and can survive in extremely high temperatures and rocky soil - the realities of farming conditions in Likotuden. Sorghum can be consumed directly as a staple food or processed into flour or syrup, or be used as livestock feed. If there is sorghum left over after a family's direct consumption, it is usually sold locally to earn additional income.

Local farmers grow and harvest sorghum once a year, and plant their crop during the rainy season. Sorghum needs sufficient water in the soil and a temperature of more than 15° C for planting.[1] Most sorghum takes four to five months to reach maturity,[2] with the best time for harvest when the moisture content of the grain is below 20 percent.

Before storing sorghum, local farmers thresh and dry it under the sun. They usually store the grain in their *lumbung* - a traditional warehouse - using traditional woven bags. This project focused on finding the most effective storage method for sorghum, which is vulnerable to loss due to weevils.

LOCATION

[1] Jean du Plesis. (2008). Sorghum Production. Department of Agriculture, South Africa
[2] Department of Agriculture and Fisheries Queensland Government. Overview of Sorghum Industry

HYPOTHESIS

We hypothesized that the number of surviving weevils would be further reduced when compared to phase one by completely filling the container with grain and keeping it sealed for six months, restricting the amount of oxygen available to these pests.

METHODOLOGY

Kopernik rapidly tests innovative solutions in last mile contexts in order to determine their potential to reduce poverty. In our experiments, we adopt a lean approach, collecting and analyzing small-scale data to learn the effectiveness of the solutions.

In this project, we tested two storage methods:

1. A hermetic plastic bag placed inside the traditional woven plastic sack with a 60kg capacity; and
2. A hermetically sealed plastic drum with a 180kg capacity.

We compared these methods against the traditional woven plastic sack (60kg).

Each container was sealed and kept in a *lumbung* for six months. After six months, we took 600 grams of sorghum as a sample from each storage container and measured the following indicators:

1. Number of weevils, alive;
2. Number of weevils, dead;
3. Moisture level.

FINDINGS

Number of Weevils (Dead and Alive)

We measured the performance of each container in protecting the grain from weevils by manually counting the number of weevils (both dead and alive) in the sample for each storage method.

Image 1. A Kopernik Analyst manually counts the number of weevils inside each storage solution

We found that:

- The fully packed 180kg hermetically sealed plastic drum had the lowest number of weevils (11 alive, 0 dead), proving it was the most effective storage method;
- The hermetic plastic bag and the traditional woven sack still had a significant amount of weevils present, (295 alive, 10 dead; and 510 alive, 12 dead respectively); and
- Each of the storage methods performed better than the findings produced in phase one.

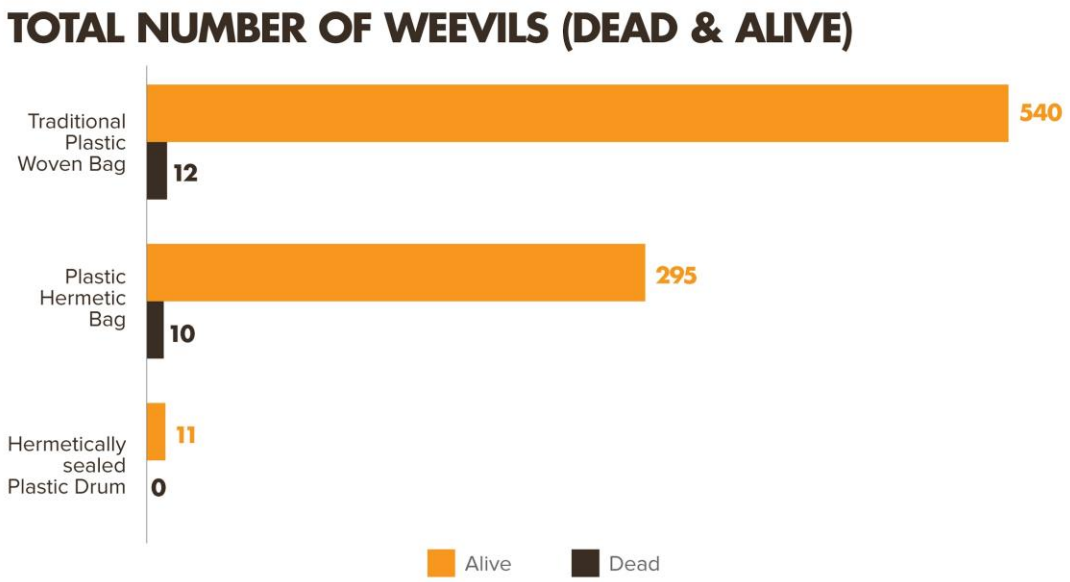

Figure 1: Total number of dead and alive weevils found among three different storage methods

In phase one, the two hermetic storage containers performed similarly which raised the question why this was not the case under these modified conditions. Upon further investigation, we learned the unexpected results for the hermetic plastic bag was due to the presence of holes in the bag, rendering the hermetic seal broken. Our assumption is that these holes were caused by the weevils chewing through the plastic in search of oxygen. Studies in Zimbabwe[3] and Kenya[4] also showed the same conditions, where their GrainPro hermetic bags were perforated by weevils. An oxygen level as low as five percent can ensure a weevil's survival[5]. This would also explain why the hermetically sealed plastic drum had the best result as the heavier plastic was not able to be breached - or eaten - by the weevils.

[3] F.E. Dowell and C.N. Dowell., 2016. Reducing Grain Storage Losses in Developing Countries. Wageningen Academic Publisher.

[4] De Groote, H., Kimenju, S.C., 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

[5] Emekci, M., Navarro, S., Donahaye, J.E., Rindner, M. and Asrieli, A., 2001. Respiration of stored product pests in hermetic conditions. In: F.E. Dowell and C.N. Dowell., 2016. Reducing Grain Storage Losses in Developing Countries. Wageningen Academic Publisher

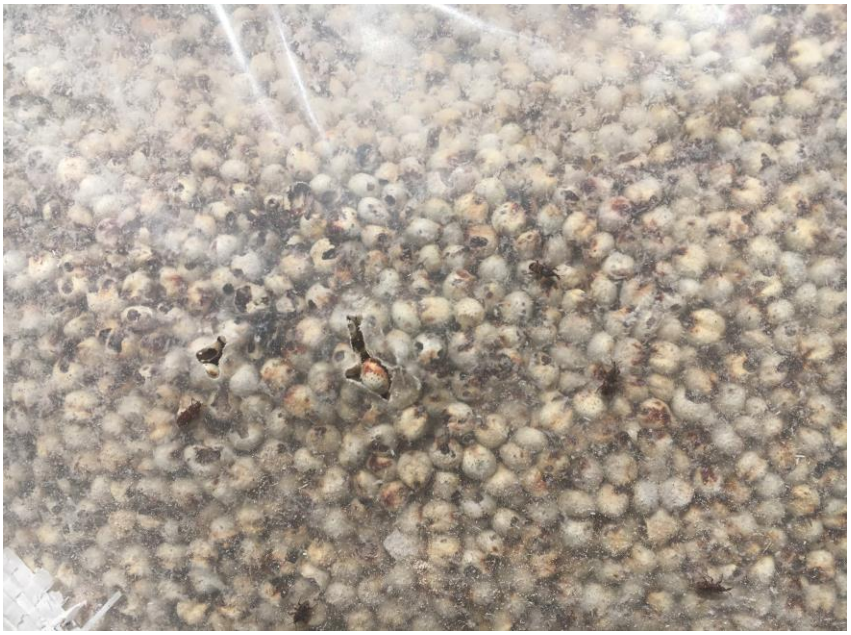

Image 2. Holes were observed on the surface of the hermetic plastic bag, breaching the hermetic seal.

Moisture Level

Moisture level is also important for sorghum storage because sorghum is susceptible to aflatoxin, a naturally occurring toxin produced by certain fungi. If aflatoxin-contaminated crops are consumed by humans, aflatoxin poisoning can occur.

Image 3. A Kopernik Senior Analyst measuring the moisture level of the stored sorghum using a moisture meter

The Food and Agricultural Organisation (FAO)[6] recommends that sorghum grains' moisture level should not exceed 14.5 percent for direct human consumption.

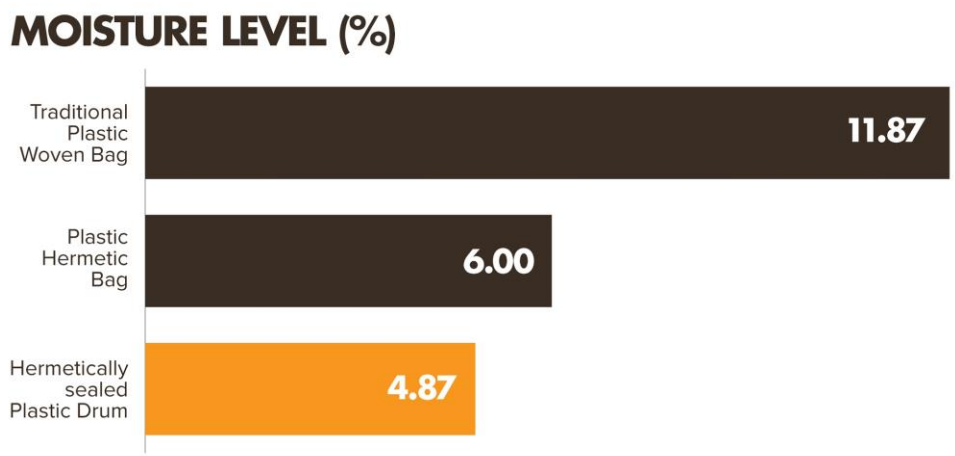

Figure 2: Moisture level comparison among three different storage methods

The graph above shows that all storage methods maintained a moisture level under 14.5 percent with the hermetically sealed plastic drum performing better (4.87%) than the hermetic plastic bag (6%) or the traditional plastic woven bag (11.87%). In other words, grains stored in all tested solutions are not contaminated by aflatoxin and therefore safe for human consumption.

Characteristics of Weevil Infestation

The existence of weevils affects the appearance of the sorghum grains. When weevils are present, the grain is hollowed out and a powder residue is usually found in the bag. The female weevils chew a small hole in the grain, depositing her eggs inside.[7] When the eggs hatch, the larvae feed on the inside of the grain until the weevil is fully grown. Among the three different storage methods, the traditional woven sack had a higher indication of powder translating into a higher level of weevil infestation.

[6] FAO, Sorghum: Post Harvest Operations, the Codex Alimentarius Commission has established global standards for sorghum grains under Codex Standard 172-1989

[7] Penn State College of Agricultural Science. Weevils on Stored Grains

Image 4. Weevils hollow out the sorghum grain leaving powder in the bag

Rodent Breach

There was no evidence of a rodent breach, identified by bite marks, in any of the three storage methods observed by Kopernik.[8]

Phase One Project Comparison

As depicted in the graphs below, both the total number of weevils present and the moisture level were greatly reduced for all storage methods in phase two. The biggest reduction was observed in the hermetically sealed plastic drum with a 98 percent reduction, followed by the traditional plastic woven bag with an 80 percent reduction and the plastic hermetic bag with a 69 percent reduction.

[8] However, based on conversation with a farmer in the area who has been using hermetic bags to store sorghum for five months in their warehouse, rodent and ant breaches were observed

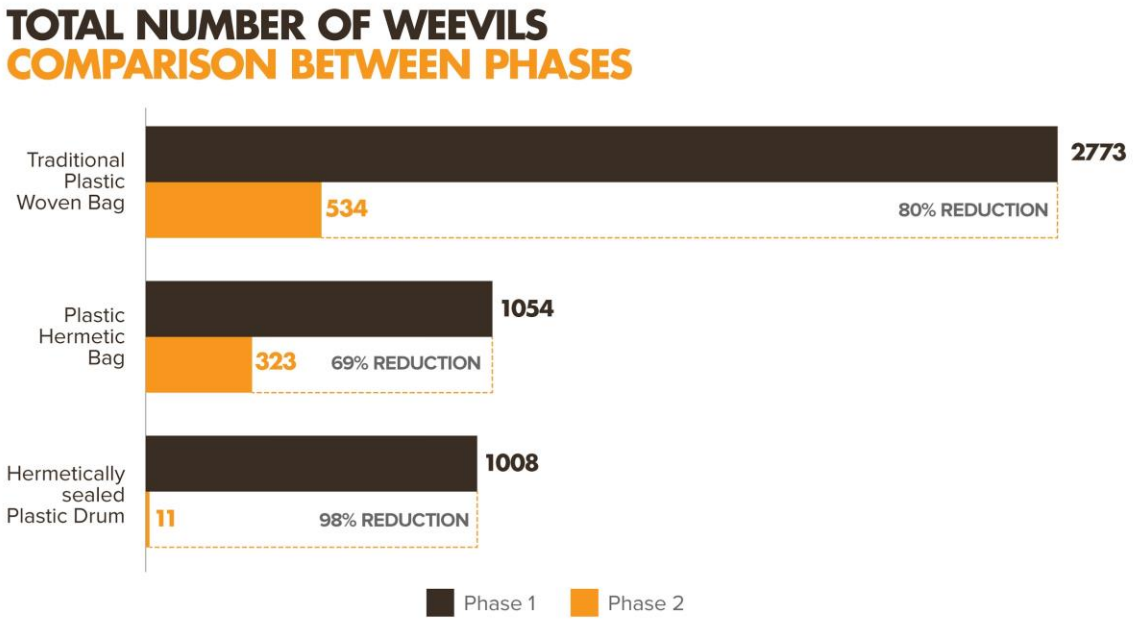

Figure 3: Comparison of total number of weevils and the percentage reduction in phase one and phase two

As represented in the graph below, the biggest reduction in moisture can be observed in the hermetically sealed plastic drum with a 63 percent reduction, followed by the plastic hermetic bag with a 57 percent reduction and the traditional plastic woven bag with a nine percent reduction.

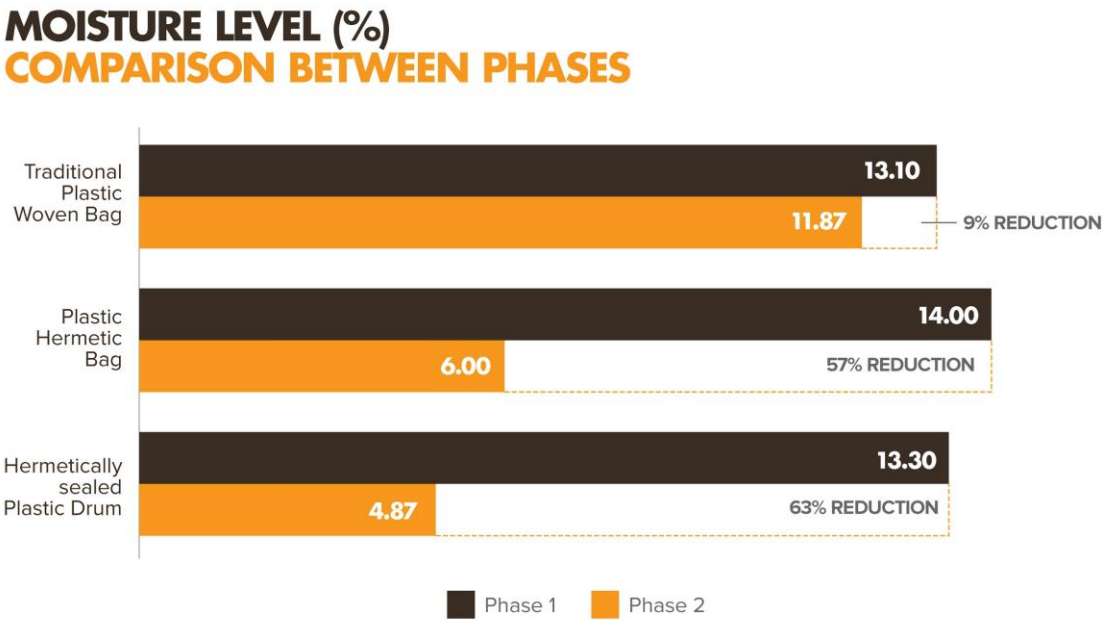

Figure 4: Comparison of moisture level in phase one and phase two

CONCLUSION

Based on Kopernik's data analysis and observation, we conclude that our hypothesis was correct: filling the container to capacity and keeping it sealed for six months provides a better result than the approach adopted in phase one - opening each storage method and counting the weevils every month for six months.

In phase one, Kopernik deemed the plastic hermetic bag as the best option when taking into consideration four criteria: weevil numbers, moisture level, rodent breaches and affordability for farmers. Both the plastic hermetic bag and the hermetically sealed drum had similar results in phase one in terms of weevil numbers (1,003 & 1,054 respectively) and moisture level (13.3% and 14% respectively). However, it was the plastic hermetic bag that performed significantly better in terms of cost, as the plastic hermetic bag is more affordable for farmers at IDR 27,500 (~US$2) with a 60kg capacity, while the hermetically sealed plastic drum cost IDR 350,000 with a capacity of 180kg (~US$26) or IDR 116,666 (~US$8) per 60kg.

In phase two, however, there has been a shift towards the hermetically sealed plastic drum being the most effective solution despite the higher cost. The moisture level was reduced to 4.9 percent and only 11 alive weevils and no dead weevils found. The plastic hermetic bag reached a 6 percent moisture level and 295 alive weevils and 10 dead weevils, a better result than phase one. With the discovery of holes in the bag rendering the hermetic seal broken, Kopernik would not support the plastic hermetic bag as a long-term solution.

Kopernik understands that for smallholder farmers it may not be realistic to store grain and not open the container for six months. We therefore believe an option with more flexibility needs further investigation.

TESTIMONIAL :

I have been using hermetic bags to store sorghum for the past five months. There are no weevils inside the hermetic bags! However, because I store my bags in my milling factory I'm worried about ants and rodents as I have begun to see some evidence of those pests.

- Maria Loretha, Sorghum Farmer

RECOMMENDATION

Based on the data collected, Kopernik recommends that:

1. More research is conducted into the storage habits of sorghum farmers to learn whether sealing a drum for six months is realistic or if more flexibility is needed;[9]
2. Kopernik conducts another round of tests to determine whether a better result can be obtained if a natural pesticide is used in conjunction with the storage containers.

A phase three experiment will be implemented by Kopernik. In this experiment, we will test the same storage solutions and mirror the conditions for phase one and for phase two, adding a natural pesticide called Diatomaceous Earth (DE). We hypothesize that DE will reduce the number of weevils compared to the previous experiment results and allow the farmers to open the container periodically. Additionally, we will store the storage solutions inside a permanent building, replacing the wooden *lumbung* to see whether this will also maximize the results.

[9] Sealing and not opening the grain storage for six months is great to reduce the number of weevils, but that means farmers can't open it for direct consumption as well

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FINDING WHAT WORKS

LEARN MORE

Kopernik's "Increasing Farmer Food Security and Incomes: Phase One" project report details our findings which led to the modifications and research method carried out as part of phase two.