


INCREASING FARMER FOOD SECURITY AND INCOMES: GRAIN STORAGE SOLUTIONS PHASE THREE

EXPERIMENTATION RESULT

Tungga Dewi Winarno Putri

March 2019

KOPERNIK

INCREASING FARMER FOOD SECURITY AND INCOMES: GRAIN STORAGE SOLUTIONS PHASE THREE

This project focuses on reducing post-harvest losses of grain during storage due to weevil infestation. In the first phase of the project, we found that the number of weevils in hermetic bags and hermetic drums were 50 percent lower than traditional storage methods (woven plastic sack), but a significant number had still survived. We believed this was because the containers were opened for testing once per month (for six months), providing oxygen to the weevils which potentially helped them to survive. Based on these findings, the second phase of the project tested the same solutions but we only opened the storage containers once - at the end of the six-month period. We found on average an 80 percent reduction in weevil numbers across all storage methods, with the hermetic drum producing the best results.

Kopernik was then interested in testing whether there is a solution to make the containers more appropriate to the needs of farmers, enabling them to open the containers periodically to access grain as needed, but still achieving better results than phase one and two. We therefore decided to add a natural insecticide, Diatomaceous Earth (DE) to the three different storage methods, replicating this scenario across two groups. In the first group (Group A), the containers were opened each month over a six-month period, similar to phase one, while in the second group (Group B), the containers were only opened after the six-month period ended, similar to phase two. During the data collection process, we counted the number of weevils, measured moisture content, and checked whether there were rodent breaches for each storage method.

Our experiment concluded that:

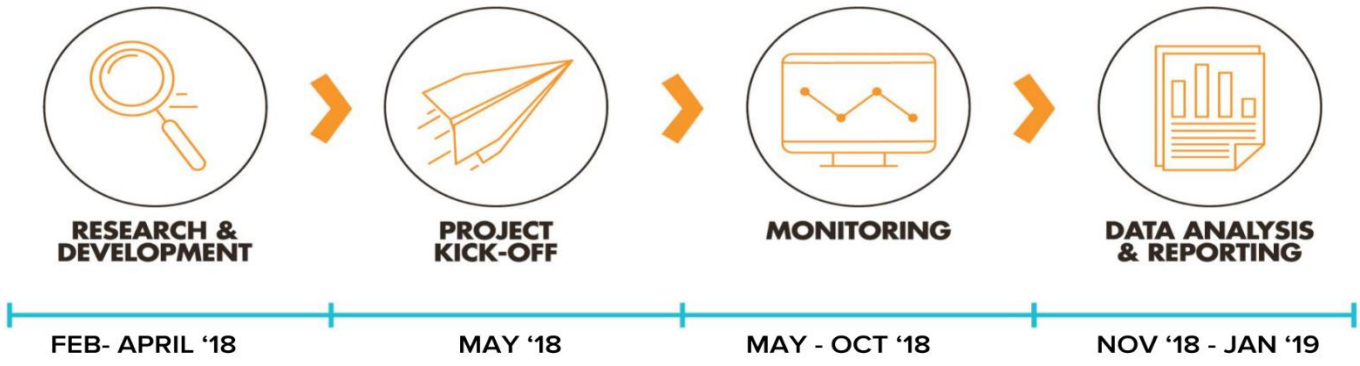
- All storage containers had a significant weevil reduction of 98 percent and 88 percent compared to phase one and two respectively;
- The moisture content of sorghum was much lower with the presence of DE than without; and
- Adding DE to a storage method can increase a farmer's income by 87 percent regardless of the storage method used[1].

Special points of interest:

- Adding a natural insecticide, Diatomaceous Earth (DE) reduced 98% weevils number across all storage method.

Content

TIMELINE



[1]When extrapolated over a three-year time period

CONTEXT

Sorghum is a type of cereal grain that is well suited to the dry environment of Flores. It is a self-pollinating plant that is more drought resistant than corn, wheat, soybeans, and other crops[2]. Sorghum used to be the main staple food in Flores, however it's popularity decreased when people began switching from sorghum to rice and corn[3]. The crop started to gain recognition again in 2007 when Maria Loretha, a local entrepreneur, helped sorghum regain popularity by empowering farmers in Likotuden, East Flores Regency, to produce and sell sorghum products[4].

This project focused on finding the most effective storage method for sorghum, which is vulnerable to post-harvest loss due to weevil infestation. Farmers usually store their grain in traditional woven bags in their *lumbung* - a traditional-style wooden warehouse. According to field interviews, farmers can lose between 40-70 percent of their stored grain due to weevil infestation. A similar global study showed that farmers lose around 50 percent of their crops when storing them using traditional methods around the world[5].

In the first phase of the project, Kopernik tested two simple hermetic (sealed with no air entering) methods, a hermetic storage bag and hermetic storage drum and compared it with the traditional storage method over a six month period. We found that the number of weevils in the two hermetic storage solutions were 50 percent lower than when using traditional storage, however we still found that a thousand weevils survived in the hermetic solutions.

We believed this happened because each time the containers were opened for data collection (once per month for six months), oxygen entered and helped the weevils survive. We also considered that one of the solutions - the hermetic drum - was only 30 percent full, creating space for oxygen which may also have assisted the weevils to survive. Building on these findings, in the second phase of the project we filled all three storage containers to capacity with sorghum and sealed them for six months, without opening them during this period. We found that under these conditions, on average there was an 80 percent weevil reduction across all storage methods.

In phase three, Kopernik wanted to determine whether there was a way to make the containers more responsive to the needs of farmers, enabling them to open the containers periodically and enabling them to access the grain, but still having better results than phase one and two.

---

[2]US Grain Council (na). Sorghum Handbook: All About White Sorghum. US Grains Council

[3]BBP2TP (2017), Balitbangtan Kawal Lahirnya Kembali Sejarah Sorghum di NTT, Balai Besar Pengkajian dan Pengembangan Teknologi Pertanian.

[4]Ebed de Rosary (2016), Suskses Kembangan Sorghum di NTT, Maria Akui Jatuh Cinta pada Rasa Pertama, Mongabay Situs Berita Lingkungan

[5]Costa S.J. Reducing Food Losses in Sub-Saharan Africa (Improving Post-Harvest Management and Storage Technologies of Smallholder Farmers) UN World Food Programme; Kampala, Uganda: 2014, also found in E. Mondal & K. Chakraborty (2017). Observation on the extent of grain damage by rice weevil with respect to the presence of few phyto-chemicals in the rice grain. Research Journal of Life Science, Bioinformatics, Pharmaceutical and Chemical Sciences

HYPOTHESIS

Kopernik hypothesized that by using a natural insecticide, Diatomaceous Earth (DE), in the traditional plastic woven sack, hermetic bag and hermetic drum, we will reduce the number of surviving weevils in the storage containers compared to phase one and achieve comparable results to phase two. We believe that this solution will reduce grain losses during storage for farmers.

METHODOLOGY

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

In this experiment, we replicated the treatment from the two previous phases of the experiment and added DE to all storage methods in both groups. Diatomaceous Earth (DE) comes from diatomite sedimentary rock that has been crushed into a sand-like powder. The rock naturally occurs from the accumulation of the amorphous silica (opal, SiO2 CnH2O), the cell walls of dead diatoms, a type of microscopic single-cell aquatic plant (algae)[6]. DE causes insects to dry out and die by absorbing the oils and fats from the cuticle of the insect's exoskeleton. Food grade DE is safe for human consumption.

Over a six-month period, we took 600 grams of sorghum as a sample in each storage method. We collected the sample monthly for six times in Group A and once (after after six months) in Group B. During the experiment, we measured the following indicators:

- Number of weevils, alive and dead; and
- Moisture level.

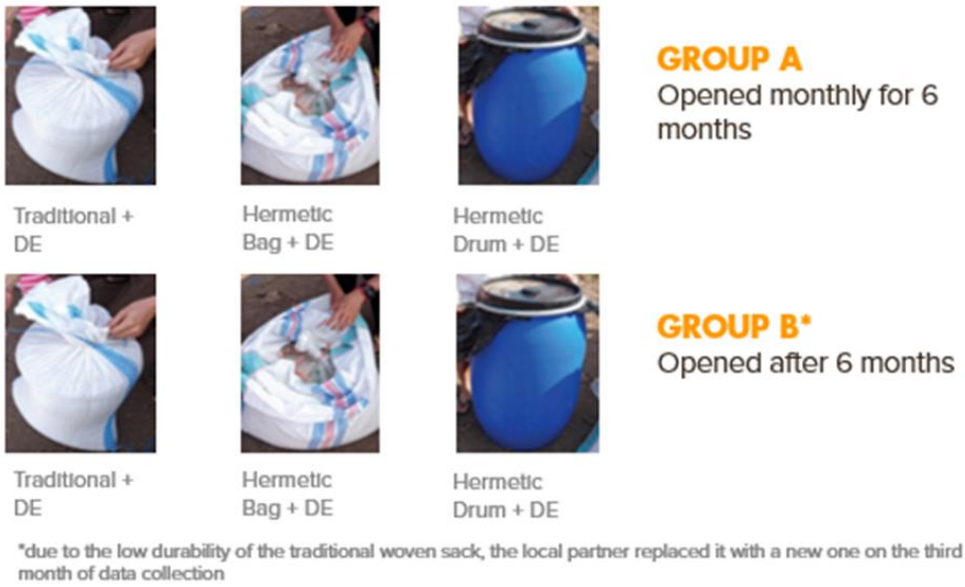


Figure 1. The conditions for group A and group B

[6]Llyod E. Antonides (1997). Diatomite. US Geological Survey Mineral Resources Program

FINDINGS

Number of Weevils

We measured the performance of Group A and B for each storage method by manually counting the number of weevils (both dead and alive) in the sorghum samples.

During the first five months of data collection for Group A (May-September), we found no weevils present in any of the storage methods. It was only in the final month that we found a small number of weevils in the three containers. Similar to findings in the two previous phases, the hermetic drum was found to be the most effective storage method with only two weevils found in both Group A and B. We also found that the traditional woven sack in Group A (42 weevils) performed better than in Group B (225 weevils) despite being opened every month.

Even though in phase two we found that keeping the bags closed for six months rendered a better result than being opened monthly for six months, in this phase we found the opposite, that the number of weevils in Group A (opened monthly) was lower than Group B, especially with the traditional sack. We learned that due to its low durability, the traditional woven sack needs to be replaced every 1.5 months. In phase two, even though we intended to keep the sorghum sealed for six months across all storage methods, we later learned that the farmer still replaced the traditional woven sack with a new one every 1.5 months to keep the sorghum safe. To correct this treatment, in this phase we replaced the traditional woven sack less frequently than in phase two. This might explain why the final results had a higher number of weevils in the traditional method that was sealed for six months (Group B) compared to the one opened monthly over the six month period (Group A).

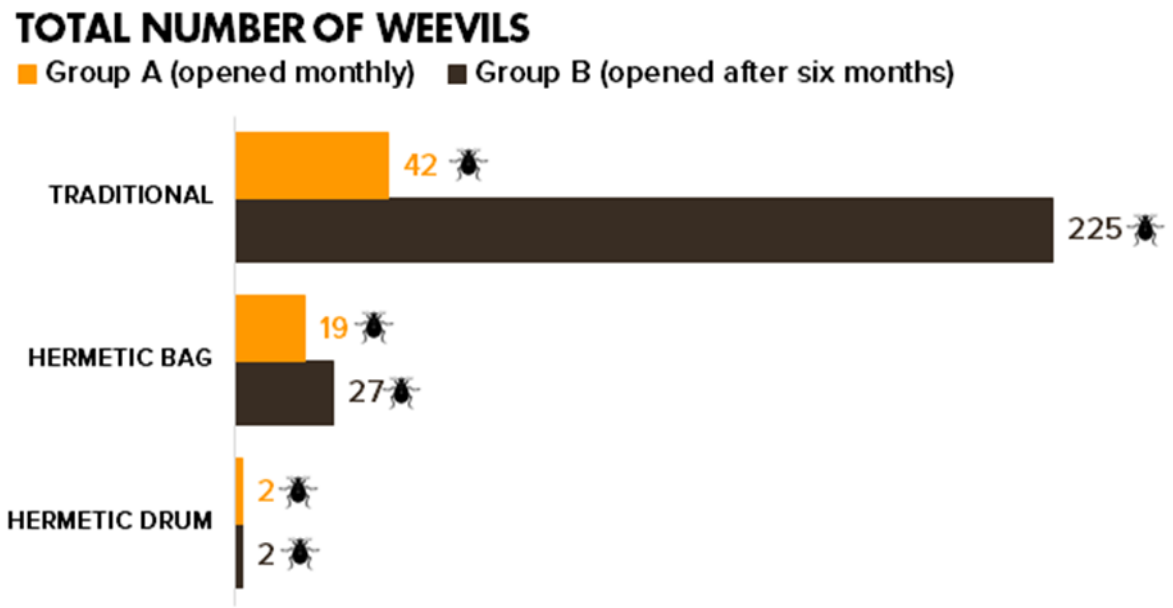


Figure 2. Total number of weevils found in the three different storage methods in both groups

FINDINGS

Comparison Weevil Presence Between Phases

Based on previous findings of our experiments, we found that storing grain in hermetically-sealed plastic drums filled to full capacity (meaning filled to the top) – and keeping them sealed (without opening the container during the storage period to take out grain) – was the most effective way to keep the weevils out. However, we acknowledged that this solution might not be optimal as farmers need regular access to stored grain more frequently.

After adding DE to each storage method and replicating the previous experiments, we found that adding DE could reduce weevil numbers by 98 percent in Group A and 88 percent in Group B. These findings indicate that the application of DE to stored grain can give farmers the flexibility to periodically check or use their grain while still minimizing storage loss. The farmer can even continue their current practice of using the traditional woven sack and replacing it every 1.5 months to account for its low durability.

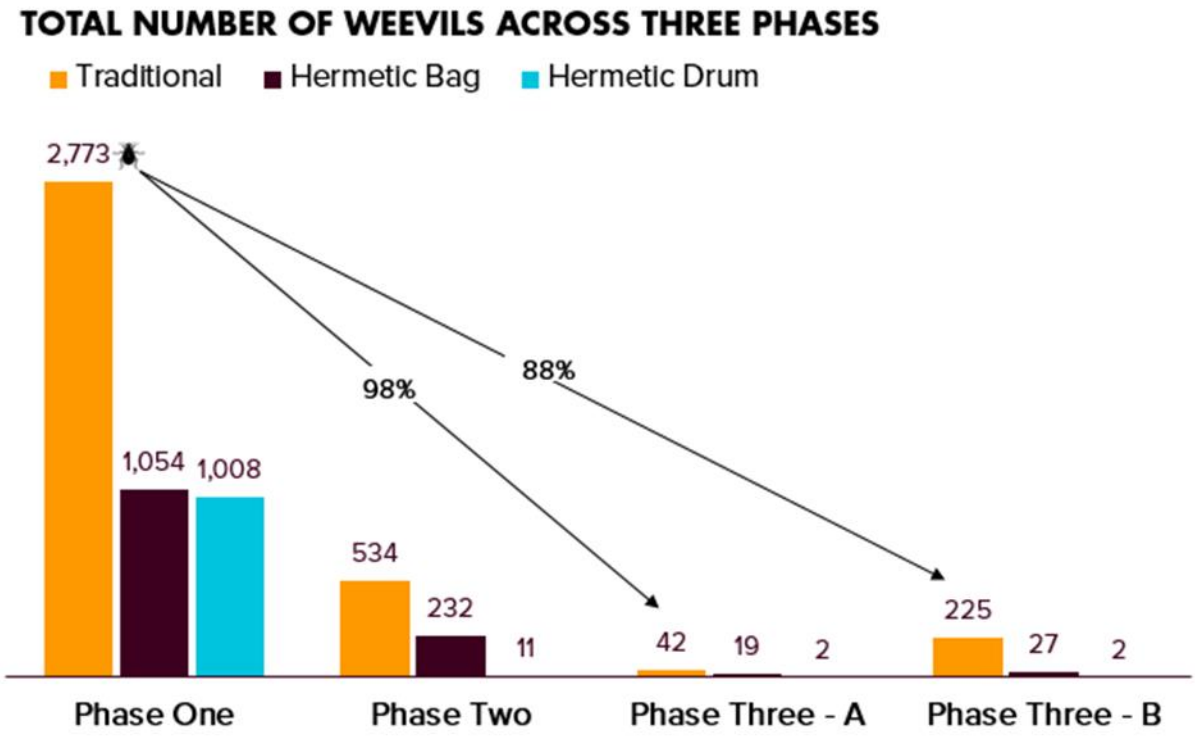


Figure 3. The comparison of the total number of weevils across three phases

Moisture Level and Rodent Breaches

Moisture content is important for storing sorghum. A high moisture content will affect the humidity of the grain inside the container and trigger mold growth, making it unsafe for human consumption[7]. Conversely, if the sorghum is too dry, it will shrink, lose weight, and be easily damaged during handling[8]. Therefore, The Food and Agriculture Organisation (FAO) recommends a maximum moisture content of 14.5 percent for storing sorghum with no minimum value stipulated[9].

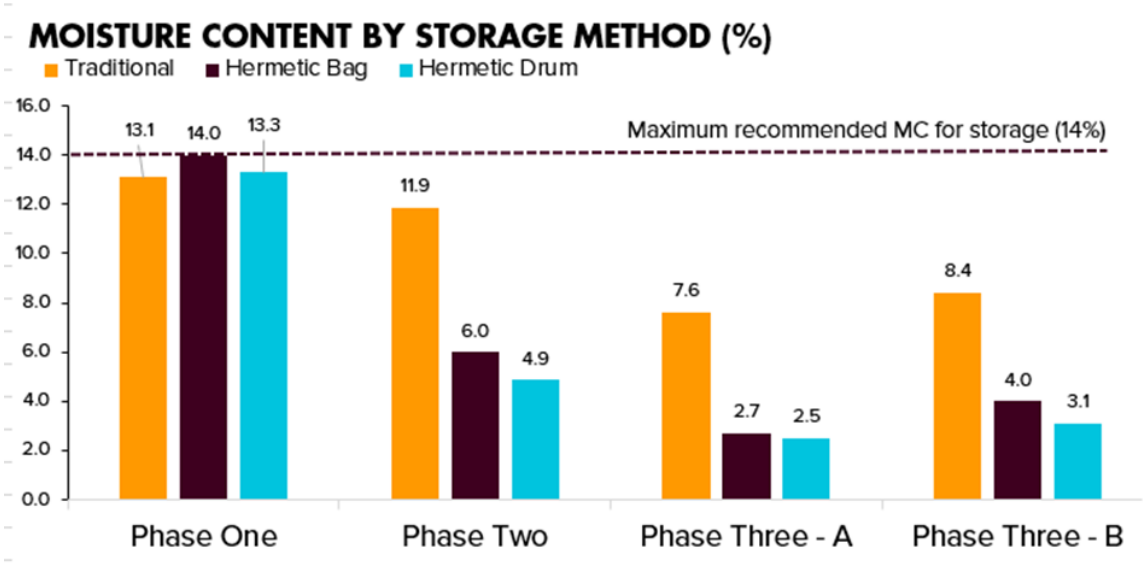


Figure 5. The comparison of the final moisture content by storage methods in the three different phases

Our data shows that the moisture content across the three different storage methods is lower than 14.5 percent, therefore the grain is still safe for human and/or animal consumption. We also found that the moisture level with DE application was much lower compared to the previous phases. This may be a result of the dehumidifying properties of DE. We observed the physical condition of the grain and found no shrinkage or weight reduction. Another possible reason for the low moisture content however could be that the DE coated the tool's probe and lowered the moisture meter's reading[10].

We also observed that there was no evidence of rodent breaches during the experiment, based on the absence of evidence of rodent bite marks on any of the storage containers.

[7]Ratnavathi CV et al (2012), Natural occurrence of aflatoxin B1 in sorghum grown in different geographical regions of India. Journal of the Science, Food, and Agriculture

[8]TSGC (na). Is Grain Moisture Content Throwing a Wet Blanket on Your Profits? Tri-States Grain Conditioning (TSGC): Grain Storage Made Better

[9]Food Security Department (1999), Sorghum: Post Harvest Operations, Natural Resources Institute, edited by Danilo Mejia (Technical), Beverly Lewis (Language & Style) (AGSI/FAO)

[10]DE has mineral properties that is widely used to improve coating in the painting industry. Therefore, it is likely that DE coated the moisture meter probe and affect the reading result.

Economic Analysis of Storage

Following the three phases of testing and the positive impact of DE in reducing weevil numbers, we were interested to see the potential economic benefit that farmers could gain across all storage methods. Based on our interviews, a farmer in East Flores can harvest sorghum up to three times per year and sell their sorghum for IDR5,000 (US$0.35) per kg. In one harvest, we assumed that a farmer can harvest a minimum 150kg sorghum which equals to 450kg of sorghum per year.

Considering the costs of storage and DE, sorghum loss, and the revenue that a farmer can receive from selling the sorghum at IDR5,000 per kg, we calculated a cost/benefit analysis for a three year period, which is the estimated lifespan of the hermetic drum. Even though the cost between the traditional sack, the hermetic bag and the drum differed greatly, the higher upfront costs of the hermetic methods, especially the drum, were offset by their longer lifespans. We found that over three years, a farmer can only gain US$220 profit from selling sorghum if he keeps using the traditional woven sack method for storing sorghum. However, their profit could increase by 65 percent to US$365 if they switched to using hermetic solutions (Figure 6).

Experiment Phase	Storage Method	Sorghum Loss	Storage Cost	Profit	% Increase
Phase One	Traditional	50%	$19.17	$220.46	N/A
	Hermetic Bag	20%	$19.17	$364.23	65%
	Hermetic Drum	20%	$17.75	$365.65	66%
Phase Three	DE + Traditional	1.0%	$63.90	$410.56	86%
	DE + Hermetic Bag	0.5%	$63.90	$412.95	87%
	DE + Hermetic Drum	0.5%	$62.48	$414.37	88%

Note: 1) The calculation made over a three-year period; 2) Storage cost estimation is based on a 150 kg sorghum production capacity per harvest season; 3) Loss percentage is based on the weevil data and interviews; 4) The three year net benefit is based on the estimation that a farmer can produce 450 kg of sorghum annually and sell it for IDR5,000 per kg.

Figure 6. The monetary benefit of the different storage methods compared to the traditional method

Interestingly, with the addition of DE equalizing the three storage methods' performance in reducing weevil infestation, we found that once farmers add DE to their storage method, they could potentially increase their profit by 87 percent regardless of the storage method used. This means that as long as the farmers use DE, they can use any of the three storage methods, including continuing to use the traditional sack, to gain the same level of profitability as the hermetic solutions.

CONCLUSION

The result of the experiment proves that the application of DE to grain during storage can reduce post-harvest loss by 98 percent. The result of the experiment shows significant improvements from previous phases during which DE was not applied.

Meanwhile, in terms of the moisture content, DE acts as a dehumidifier, resulting in much lower grain moisture content and therefore a very low risk of spoilage due to mold. Even though the moisture levels were very low we did not find any shrinkage of the sorghum in terms of weight and the grain did not appear brittle or easily damaged.

Acknowledging the benefit of significant weevil reduction, and the relatively small investment of US$5 per 150kg (which is likely to be cheaper for larger quantities) for applying DE, we were able to calculate that adding DE can increase farmers' revenue by up to 87 percent regardless of the storage method used.

RECOMMENDATION

Based on the results of this experiment, we recommend that Kopernik investigates:

- How to make DE accessible to farmers in the last mile; and
- How to test the application of DE on a larger scale in different locations and/or with different grain types.

LEARN MORE

Kopernik's Senior Analyst, Riesa Putri from the Solutions Lab team recently published a Kopernik Insight, concluding that adding DE can reduce weevils infestation by up to 98 percent.