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Management of Maize Weevil (*Sitophilus zeamais*) Using Hermetic and Non-Hermetic Storage Containers: A Short Communication

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ABSTRACT
Background and Objective: Maize is one of the most important food crops in developing countries. The maize weevil, *Sitophilus zeamais*, is one of the most important post-harvest pests of the crop. This study was conducted to evaluate the effects of hermetic and non-hermetic containers as well as black polythene plastic bags treated in the sun on maize weevil survival and seed viability. **Materials and Methods:** The treatments were three unreplicated black polythene plastic bags and two plastic water bottles. The black polythene plastic bags were prepared manually. In each of these containers, 150 g of undamaged, weevil-free maize grain was added along with 15 live adult maize weevils. One of the plastic water bottles was kept hermetically sealed, while the other was perforated to allow air entry. The black polythene plastic bags were tightly sealed and put in the sun at a mean temperature of 30°C for 20 min, 40 min and an hour, respectively. Treatments of the plastic water bottles were kept for a week. Data were analysed using Excel software. **Results:** The oxygen depletion resulted in 100% adult weevil mortality after a week in a hermetic container. The black polythene plastic bags exposed to the sun for 40 min to 1 hr resulted in 100% adult mortality. The germination test results in this study indicated that black polythene plastic bags exposed to the sun for a maximum of an hour and above resulted in decreased germination capacity. **Conclusion:** The hermetic containers and black polythene plastic bags were thus found to be effective against maize weevil control.

KEYWORDS
Hermetic, non-hermetic, sun-treated, maize weevil, *Sitophilus zeamais*

INTRODUCTION
Maize is one of the most important food crops in developing countries[1]. Although Ethiopian maize production is largely seasonal, the country's annual consumption is quite consistent[2]. Therefore, to ensure their food security and receive higher prices for the surplus they sell, farmers must preserve their maize. The maize weevil, *Sitophilus zeamais*, is the primary storage insect pest of stored maize grain. It causes significant losses in stores. According to estimates, maize weevils infest 20-30% of the stored maize in Ethiopia. Demissie *et al.*[3] reported that 100% damage has been found in maize stored for 6-8 months in the Bako area of the country. It was also reported that weevil infestation levels of 11-59% were recorded in husk-covered maize in the same area[4].

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Traditional storage approaches have so far been successful in managing storage insect pests due to the favorable climate[5-7]. Climate change, however, is anticipated to hasten the development and activity of stored product insect pests as well as the degradation of grain protectants[8]. To secure stored goods and prevent losses brought on by traditional storage buildings' shortcomings, more efficient grain storage structures were developed.

According to Tefera *et al.*[9], metal silos, a hermetic technology that has been used and adopted by farmers in Central America since the early 1990s and in Africa since 2008, are effective in lowering grain damage and losses due to insect pests. According to the on-station test, maize weevil and larger grain borer can be effectively controlled by metal silos without pesticides[10].

Hermetic storage protects the storage ecosystem from the external environment. Respiration within the storage habitat results in O_2 decrease and CO_2 accumulation, which induces weevil suffocation and dehydration[11].

One of the main objectives of improved storage techniques is to reduce the levels of post-harvest pest infestation, particularly insect pests like maize weevil and bigger grain borers, to diminish grain damage and weight loss. Hermetic bags, a more advanced storage method, have decreased gas exchanges between stored maize and the environment. Insects suffocate and die when the oxygen supply is exhausted[12]. Additionally, metabolism is decreased and fungal growth is halted, which enhances grain quality preservation. Because of this, farmers who utilize hermetic bags can anticipate having more and better-quality grain to use or sell, improving their food security and increasing their farm profitability from selling quality maize, especially during periods of market shortage and high pricing. With the recent climatic changes that mostly favor insect pests, traditional pest management methods need to be improved, utilized and widely adopted. The effectiveness of improved storage structures against maize weevil and their adoption is minimal in the Jimma zone, where maize is the most stable food for society. This short study was therefore conducted to evaluate the effects of some storage methods and conditions on maize weevil management and their effect on the viability of stored maize grain.

MATERIALS AND METHODS

This study was conducted in 2017 at the Jimma University College of Agriculture and Veterinary Medicine's Entomology Laboratory. The study was conducted using maize grain, black polythene plastic bags, plastic water bottles, plaster, sensitive balance, petri dishes and blotter papers as study materials. The treatments were three unreplicated black polythene plastic bags and two plastic water bottles. The black polythene plastic bags were prepared manually. In each of these containers, 150 g of undamaged, weevil-free maize grain was added along with 15 live adult maize weevils. One of the plastic water bottles was kept hermetically sealed, while the other was perforated to allow air entry. The black polythene plastic bags were tightly sealed and put in the sun at a mean temperature of 30°C for 20, 40 min and 1 hr, respectively. Treatments of the plastic water bottles were kept for a week. Data on the number of dead weevils and germination tests were collected. The germination test was done only for the black polythene plastic bags. The dead weevils were determined based on the criteria of previous study[13]. Weevils that were found curled up, with their legs outstretched, lying on their side or back, immobile or not attached to the maize kernels, flowing with the kernels when the plastic water bottles were tilted, hard to the touch, or having any combination of these characteristics, even when exposed to ambient air, were therefore assumed to be dead.

Data analysis: Excel software was used for data analysis.

RESULTS AND DISCUSSION

The results from the black polythene plastic bags showed that all weevils exposed to the sun dried due to the high heat inside the bags and suffocation. Except for the black polythene plastic bag exposed to

Table 1: Effects of hermetic and non-hermetic storage methods on maize weevil survival

Treatment	Number of dead weevils	Percent of dead weevils
Polythene plastic bags		
20 min	9	60
40 min	15	100
1 hr	15	100
Hermetic plastic bottle	15	100
Non-hermetic plastic bottle	2	13

the sun for 20 min and the non-hermetic bottle containers, 100% of weevils have died in all treatments. These results showed that hermetic storage structures isolate storage ecosystems from the outside environment, while respiration within the ecosystem results in O_2 reduction and CO_2 accumulation, which causes weevils to suffocate and become dehydrated[11,14]. These results indicated that black polythene plastic bags exposed to the sun for less than 1 hr and hermetic containers can inhibit weevil survival due to high heat inside and a lack of oxygen (Table 1). This result agreed with the findings of Demmirew *et al.*[15] that the highest rates of maize weevil and Angoumois moth mortality were recorded when grain was exposed to the sun heat using a black polyethylene sheet. Similarly, findings of Ajayi *et al.*[16] also suggested that solar heat exposure of *Callosobruchus maculatus* eggs on cow pea seeds resulted in the death of the eggs after 24 hrs at the thermal death point. In a non-hermetic containers, only 13% of the weevils have died, indicating that storage structures that allow air circulation favor weevil survival and reproduction. This goes in line with the reports of Brumm *et al.*[17] that non-hermetic storage structures do not disturb the survival and reproduction of stored grain weevils.

The germination test results revealed 95, 70 and 60% for the sun-exposed black polythene plastic bags for 20, 40 min and 1 hr, respectively. This indicated that as the duration of exposure to heat increases, the viability of the seed decreases. This result, however, contradicted the findings of Ajayi *et al.*[16] that there were no significant differences in the germination capacity of cowpea seeds exposed to solar heat from 24 to 96 hrs using black polypropylene sheets. Brumm *et al.*[17] indicated that 100% maize weevil mortality was recorded in hermetically sealed plastic containers. A study by Somavat *et al.*[18] also showed that hermetic bags are effective in eliminating storage pests such as *Rhyzopertha dominica* in stored wheat grain. Hermetic storage technologies not only manage insect pests, but they also can manage the incidence of aflatoxin in stored maize grain[19].

Hermetic storage structures have both advantages and disadvantages. One of the key advantages is that they can efficiently store dried goods including grains, silage, coffee, cocoa and seeds, which lowers post-harvest losses to under 1% in hot, humid areas. Such storage structures can get rid of most insect infestations without the use of chemical fumigants. A further benefit of hermetic storage is that it helps stop the development of aflatoxins linked to mold, which pose a serious threat to the public's health. Hermetic storage, on the other hand, has drawbacks, including the requirement for scientific understanding of insect and animal respiration and the use of injected CO_2 to lower oxygen levels. Additionally, the relative humidity and temperature inside hermetic bags may behave similarly to the ambient circumstances, which could have an impact on how some goods are stored. Overall, hermetic storage structures are beneficial for both preservation and insect control, but they need to be carefully monitored and managed to maintain the best conditions for various commodities.

CONCLUSION

Hermetic storage and black polythene plastic bags are effective for weevil control in stored maize grain. Suffocation and high heat resulted in 100% mortality for the maize weevil. On the other hand, as heat intensity increased in the storage structures, the germination capacity of the grain decreased, indicating that despite the effectiveness of the heat in killing the weevils, it affected the viability of the stored grains. With the strict suggestion that a well-designed and replicated study on the same problem needs to be conducted to confirm the results, sun-treated black polythene plastic bags and hermetic storage structures were effective against maize weevils in stores.

SIGNIFICANCE STATEMENT

Quality and quantity losses of stored grains due to storage pests brought about the utilization of improved storage structures. Improved storage structures can store food grains for a long time. They also have a higher storage capacity than traditional storage structures. As opposed to their efficiency in managing stored grain weevils, improved storage structures are not widely known and utilized. So, this short communication was done to fill the gaps in utilizing improved storage structures.

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REFERENCES

1. Shiferaw, B., B.M. Prasanna, J. Hellin and M. Bänziger, 2011. Crops that feed the world 6. Past successes and future challenges to the role played by maize in global food security. Food Secur., 3: 307-327.
2. Gitonga, Z.M., H. de Groote, M. Kassie and T. Tefera, 2013. Impact of metal silos on households' maize storage, storage losses and food security: An application of a propensity score matching. Food Policy, 43: 44-55.
3. Demissie, G., A. Teshome, D. Abakemal and A. Tadesse, 2008. Cooking oils and Triplex in the control of *Sitophilus zeamais* motschulsky (Coleoptera: Curculionidae) in farm-stored maize. J. Stored Prod. Res., 44: 173-178.
4. Demissie, G., T. Tefera and A. Tadesse, 2008. Importance of husk covering on field infestation of maize by *Sitophilus zeamais* Motsch (Coleoptera:Curculionidea) at Bako, Western Ethiopia. Afr. J. Biotechnol., 7: 3777-3782.
5. Nagnur, S., G. Channal and N. Channamma, 2006. Indigenous grain structures and methods of storage. Indian J. Tradit. Knowl., 5: 114-117.
6. Chala, D.B., 2014. Factors affecting quality of grain stored in Ethiopian traditional storage structures and opportunities for improvement. Int. J. Sci. Basic Appl. Res., 18: 235-257.
7. Moses, J.A., D.S. Jayas and K. Alagusundaram, 2015. Climate change and its implications on stored food grains. Agric. Res., 4: 21-30.
8. Singano, C.D., B.M. Mvumi, T.E. Stathers, H. Machekano and C. Nyamukondiwa, 2020. What does global warming mean for stored-grain protection? Options for *Prostephanus truncatus* (Horn) control at increased temperatures. J. Stored Prod. Res., Vol. 85. 10.1016/j.jspr.2019.101532.
9. Tefera, T., F. Kanampiu, H. de Groote, J. Hellin and S. Mugo *et al*., 2011. The metal silo: An effective grain storage technology for reducing post-harvest insect and pathogen losses in maize while improving smallholder farmers' food security in developing countries. Crop Prot., 30: 240-245.
10. De Groote, H., S.C. Kimenju, P. Likhayo, F. Kanampiu, T. Tefera and J. Hellin, 2013. Effectiveness of hermetic systems in controlling maize storage pests in Kenya. J. Stored Prod. Res., 53: 27-36.
11. Likhayo, P., A.Y. Bruce, T. Tefera and J. Mueke, 2018. Maize grain stored in hermetic bags: Effect of moisture and pest infestation on grain quality. J. Food Qual., Vol. 2018. 10.1155/2018/2515698.
12. Baoua, I.B., V. Margam, L. Amadou and L.L. Murdock, 2012. Performance of triple bagging hermetic technology for postharvest storage of cowpea grain in Niger. J. Stored Prod. Res., 51: 81-85.
13. Gullan, P.J. and P.S. Cranston, 2014. The Insects: An Outline of Entomology. 5th Edn., Wiley-Blackwell, Hoboken, New Jersey, ISBN: 978-1-118-84615-5, Pages: 624.
14. Suleiman, R., C.J. Bern, T.J. Brumm and K.A. Rosentrater, 2018. Impact of moisture content and maize weevils on maize quality during hermetic and non-hermetic storage. J. Stored Prod. Res., 78: 1-10.
15. Demmirew, S.K., T.T. Edosa and E.A. Gutema, 2018. Ecofriendly management of storage insect pests of maize in Jimma Zone. Int. J. Adv. Sci. Res., 3: 34-38.

16. Ajayi, F.A., E. Peter, E. Okrikata, R.A.L. Emmanuel, S.A. Dattijo and E.A. Kayode, 2021. Impact of solar heat enhanced by the use of black polypropylene sheets on the development of *Callosobruchus maculatus* Fabricius (Coleoptera: Chrysomelidae) eggs and germinabilty of cowpea seeds. Int. J. Trop. Insect Sci., 41: 2867-2872.
17. Brumm, T.J., C.J. Bern and D.F. Webber, 2021. Hermetic storage of maize grain in repurposed food oil containers to control maize weevils. J. Stored Prod. Postharvest Res., 12: 42-46.
18. Somavat, P., H. Huang, S. Kumar, M.K. Garg and M.G.C. Danao *et al*., 2017. Comparison of hermetic storage of wheat with traditional storage methods in India. Appl. Eng. Agric., 33: 121-130.
19. Mutambuki, K. and P. Likhayo, 2021. Efficacy of different hermetic bag storage technologies against insect pests and aflatoxin incidence in stored maize grain. Bull. Entomol. Res., 111: 499-510.