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COST BENEFIT ANALYSIS OF THE TRIPLE-LAYER HERMETIC BAG IN MAIZE STORAGE

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ABSTRACT: This paper reports the cost-benefit analysis of the triple-layer hermetic bag, Jute and Polypropylene bags in storing maize infested with the Larger Grain Borer, *Prostephanus truncatus* (Horn) and the maize weevil, *Sitophilus zeamais* (Mot). The three bags were used to store three maize varieties (Obatanpa, Abrodenkye and Kamangkpong) for six (6) months. A factorial experiment was conducted involving 5 kg of each maize variety with moisture content between12.5-14%. These were stored in the various bags at laboratory conditions of 32 ±2 ºC and 58-88% r.h. A destructive sampling was done monthly to determine weight loss, moisture content etc. The cost benefit analysis was conducted using the cost-benefit ratio (BCR). The results show that the triple-layer hermetic bag has highest cost-benefit ratio of 1.5:1 followed by the polypropylene and the jute trailing with 1.3:1 and 1.2:1, respectively.

***Keywords*:** Cost-benefit ratio; Moisture content; *Prostephanus truncatus*; *Sitophilus zeamais*; Weight loss.

INTRODUCTION

Maize price is one of the most important factors that influence the storage of maize in Ghana (Avemegah, 1998). In areas where maize price increases throughout the year, farmers tend to hold back substantial quantities of their grain in order to take advantage of price hikes (Southwood, 1980). Many producers may sell part or the bulk of their stocks in the period directly after harvest, because of financial constraints, debts, or due to inability to protect the grains against storage losses (Jones, 2011). Maize deficit areas also experience these price hikes. Such areas usually experience price increase of over 200% to 300% from the main harvest to lean season (SRID, 2006). Insect pest damage to stored grain results in major economic losses to farmers throughout the world (Obeng-Ofori, 2008). These losses are diverse and intense, and it is estimated that approximately one-third of the world's food crop is damaged or destroyed by insects during growth, harvest and storage.

Hermetic storage (HS) technology has emerged as a significant alternative to other methods of storage that protect commodities from insects and molds (Navarro, 1994; Anankware, 2012). This technology, also termed sealed storage, airtight storage, or assisted hermetic storage, is a form of bio-generated modified atmosphere. HS is based on the principle of generating an oxygen-depleted, carbon dioxide-enriched interstitial atmosphere caused by the respiration of the living organisms in the ecological system of a sealed storage (Obeng-Ofori, 2011). The goal of this study was to assess the socio-economic benefit of the triple-layer hermetic bag, jute and polypropylene storage technologies for the protection of stored maize against infestation by *S. zeamais* and *P. truncatus* and to identify the most cost-effective technology.

MATERIALS AND METHODS

Source of materials and experimental site

The study was conducted at the African Regional Postgraduate Program in Insect Science (ARPPIS) laboratory of the University of Ghana, Legon in the Greater Accra Region of Ghana, from June, 2011 to June, 2012. The maize used for the study was purchased from farmers during the harvesting period through Agricultural Extension Officers who formed an integral part of the research team. Three different varieties of maize ("Obatanpa", "Abrodenkye" and "Kamangkpong") were used. Obatanpa is an improved variety that is given out to farmers by the Ministry of Food and Agriculture (MOFA) whiles Abrodenkye and Kamangkpong are local varieties that have been passed down to the inhabitants of Wa and Techima by their forefathers. The three maize varieties used for the study had moisture content ranging between 12 and 14%.

The triple-layer hermetic bags were supplied by the Forum for Agricultural Research in Africa, (FARA). Each triple layer bag consists of two plastic bags (made of polyethylene) put inside a third bag made of woven polypropylene to give additional protection and strength. The bags were 100 um thick and measure 34× 62cm in width and length, respectively. Ordinary bags made of polypropylene and jute sacks were bought from Madina market in Accra**.**

Experimental insects

A parent stock of adult *P. truncatus* was obtained from the entomology laboratory of the Savannah Agricultural Institute (SARI), Nyankapala, Tamale in the Northern Region and the Plant Protection Regulatory Services Directorate of the Ministry of Food and Agriculture (PPRSD/ MOFA) at Pokuase in Accra while *Sitophilus zeamais* was collected from infested stock of grains at the Madina market, Accra. These were both reared on whole maize grains in a controlled environment. Culture conditions of 28 ± 2 ºC, 65% relative humidity and 12L: 12D photo regime (Bonu-Ire, 2001) were used. The insects were placed in a plastic bowl covered with a nylon mesh and left under the sun for three hours so that insects infested with mites would die. About 100 unsexed adults were introduced into a glass jar containing 500 g of sterilized maize. The grains were sterilized in a refrigerator for 24 hours and in an oven at 40 ºC for six hours (Anankware, 2013b). After two weeks of oviposition, the parent adults were removed using an aspirator and killed by freezing. This ensured the emergence of same age progeny for use in establishing the main culture with subsequent re-culturing every two weeks. By this, insects of the same cohort were always available for the experiment.

Laboratory experiments

Effectiveness of the triple-layer bag against P. truncatus and S. zeamais

This experiment compared the effectiveness of the triple-layer hermetic bag with the other conventional storage bags (Jute and Polypropylene sack). Three unsterilized maize varieties (Obatanpa, Abrodenkye and Kamangkpong) were divided into three groups, A, B and C, respectively. These groups had three replicates each, that is, A1, A2, A3, B1, B2, B3 and C1, C2, C3. Each of these maize samples weighing about 5 kg was put into each triple layer hermetic bag and replicated 3 times. Unsterilized maize was used to simulate the actual practices used by farmers during storage. Fifty unsexed LGBs from the culture were introduced (using camel hair brush) into each of the maize samples. The bags were pressed gently to take out all the available air present in each of them. When enough air was expelled, the bags were quickly tied with plastic ropes and stored for six months. The same was done for the polypropylene and jute sacks which served as the controls.

Another set of the same maize varieties (A, B, and C) with three replicates in each sample was set up for the S. zeamais. Fifty unsexed S. zeamais were introduced into them as in above and stored hermetically for six months. In all, there were 324 experimental units of sample bags. These were stored under room conditions to simulate farmers' actual storage conditions. Destructive sampling was done monthly (i.e. 54 bags per month; 27 bags for each of the two insect species and 3 replicates of each type of bag) for 6 months of storage to determine the grain loss.

Socio-economic benefit analysis

This was conducted using the cost-benefit ratio (BCR). It was conducted in two phases vis avi cost of the storage technology (bag) and the benefits. The cost of the technology included cost of the storage bag and cost of the losses incurred during storage while the benefits included the price of the grain after storage. Cost-benefit ratio is simply the ratio of present worth of project benefits to present worth of project costs. Mathematically,

$$BCR = \sum_{t=1}^{t=n} \frac{B_t}{(1+r)^t} \Bigg/ \sum_{t=1}^{t=n} \frac{C_t}{(1+r)^t}$$

$B_=$ Benefit in each year of the project
$C_=$ Cost in each year of the project
$r =$ Interest (discount) rate
$t =$ 1, 2…n (time of the project life in years)
$n =$ Number of years in the project

A discount rate of 25% was used for all the storage bags while the project life (t) as well as the number of years in the project (n) was 1. In order to get the monetary cost of the storage losses, the cost of 5 kg of grain was obtained at GH¢6.25.00. Monetary cost of storage losses was then calculated using the following formula.

Cost (GH¢) of storage grain loss = percentage loss × cost of 5 kg grain

Or

Cost (GH¢) of storage grain loss = $\frac{Weight\ loss}{100} \times cost\ of\ 5\ kg\ grain$

Note that loss for the triple-layer hermetic bag, polypropylene and jute where 2.94%, 23.65% and 19.55% respectively. The price of grain after storage (benefits) was obtained by subtracting the monetary cost of grain loss from the initial cost of 5 kg grain (GH¢6.25). The data obtained were then substituted into the BCR formula as stated above. The technology or bag is said to be profitable when the BCR is one or greater than 1. The BCR was then compared with each storage technology to determine the most profitable one.

Analysis of results

Microsoft Excel 4.0 package was used for all statistical calculations.

An analysis of variance was performed on the transformed data with homogeneity of variance. Fisher's Protected LSD was used to separate the means.

RESULTS AND DISCUSSION

Results

Cost-Benefit Analysis

The price of grain after storage (benefits) was obtained by subtracting the monetary cost of grain loss from the initial cost of 5 kg grain (GH¢6.25). The data obtained (Table 1) were then substituted into the BCR formula.

The technology or bag is said to be profitable when the BCR is one or greater than 1. The BCR was then compared with each storage technology to determine the most profitable one. The results ranked the triple-layer layer hermetic bag 1st, the polypropylene bag 2nd and the jute bag 3rd in terms of cost-effectiveness.

Table 1. Cost-benefit analysis

Type of Storage System (bag)	Cost of technology (GH¢)			Benefits of technology GH¢		Rank in terms of cost-effectiveness
	Cost of bag	Cost of storage loss	Total cost (undiscounted)	Price of grain after storage	BCR GH¢	
Triple-layer Hermetic Bag	3.9	0.184	4.084	6.066	1.5:1	1st
Polypropylene	2.3	1.478	3.778	4.772	1.3:1	2nd
Jute	3.7	1.221	4.921	5.029	1.2:1	3rd

Cost of 5 kg of grain is GH¢6.25

APPENDIX I

The weight loss, percentage germination, moisture content, oxygen concentration and mean number of life insects in the P. truncatus infested set up

Factors Storage bag	Maize variety	Weight loss (%)	Germination (%)	MC	O_2 conc. (%)	No. of life insects/kg of grain
	Abro	4.32	37.5	14.29	5.0	5
Hermetic	Oba	7.81	46.82	14.53	5.0	7
	Ka	3.09	58.26	14.45	5.0	12
	Lsd	2.37	3.24	0.28		0.16
	Abro	26.52	25.82	13.91	21.0	977
Polypropylene	Oba	31.52	20.94	13.72	21.0	676
	Ka	25.28	25.15	13.99	21.0	891
	Lsd	2.37	3.24	0.28		0.16
	Abro	24.35	20.55	14.42	21.0	933
Jute	Oba	22.14	25.70	14.39	21.0	871
	Ka	24.29	21.59	14.33	21.0	759
	Lsd	2.37	3.24	0.28		

APPENDIX II

The weight loss, percentage germination, moisture content, oxygen concentration and mean number of life insects in the S. zeamais infested set up

Factors Storage bag	Maize variety	Weight loss (%)	Germination (%)	MC (%)	O_2 conc. (%)	No. of life insects/kg of grain
	Abro	1.91	32.73	14.25	5.0	4
Hermetic	Oba	2.89	55.98	14.23	5.0	6
	Ka	0.4	59.85	14.25	5.0	15
	Lsd	2.37	3.24	0.28		0.16
	Abro	19.82	23.92	14.0	21.0	437
Polypropylene	Oba	22.18	27.63	13.85	21.0	603
	Ka	17.05	24.53	13.96	21.0	339
	Lsd	2.37	3.24	0.28		0.16
	Abro	14.41	22.92	14.2	21.0	447
Jute	Oba	23.93	26.86	14.28	21.0	575
	Ka	10.25	23.70	14.22	21.0	380
	Lsd	2.37	3.24	0.28		0.16

Discussion

Socio-economic benefit analysis

The results showed that all three storage bags are profitable for use in maize storage. The triple-layer hermetic bag technology was however, more profitable since it recorded the highest cost-benefit ratio of 1.5: 1 followed by the polypropylene and the jute trailing with 1.3:1 and 1.2: 1, respectively. The cost-effectiveness of the triple-layer hermetic bag over the conventional bags stems from the fact that it is capable of controlling insect pests' infestation and grain losses. Although the initial cost is higher than the others, its effectiveness in quality preservation of grains coupled with its long lifespan makes it cost-efficient for grain storage.

CONCULSION

1. All three maize varieties were susceptible to *P. truncatus* and *S. zeamais.* The high yielding improved variety, Obatanpa was the most susceptible or preferred by the pests whiles Abrodenkye and Kamangkpong were the least susceptible. Susceptibility appears to be related to the ability of the insects to bore into the grains and the powder produced resulting in weight loss.

2. The triple-layer hermetic bag is more cost-effective than the jute and polypropylene bags.
3. Temperature, dew point and relative humidity variations are minimal in triple-layer hermetic bags than in conventional storage.

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