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Efficacy of insecticide incorporated bags against major insect pests of stored paddy in Sri Lanka


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Abstract

A study was conducted to evaluate the efficacy of an insecticide (deltamethrin) incorporated bags (Zerofly®) against the insect attacks during paddy storage under Sri Lankan conditions. The study was conducted at Institute of Post Harvest Technology (IPHT), Anuradhapura and the warehouse of Paddy Marketing Board (PMB), Anuradhapura. Paddy sample in Zerofly® sacks were stacked at both locations and for controls, untreated polysack bags were used. Paddy samples that were collected before storage and at monthly intervals during the storage period were analysed for moisture content, weight loss due to insect damages, Thousand Grain Mass (TGM), germination percentage, Total Milling Yield (TMY) and Head Rice Yield (HRY). Data was analyzed using Analysis of Variance (ANOVA) by Statistical Analysis System (SAS). The moisture content of paddy grains fluctuated between 13.3 – 14.3% during storage period but any significant difference was not observed among bag types. The level of insect damages in control was increased with storage time while the initial level of insect damage of treated bags remained unchanged. The mass loss due to insect damages of grains was significantly higher (p=0.05) in untreated bags than treated bags. The insect damage was reduced by 3.5-4.2% using Zerofly® bags during paddy storage. In addition, dead insect bodies were found on outer surface of the insecticide incorporated bags but no live or dead insects were found on untreated bag surface during storage. Mainly rice weevil (Sitophilus oryzae) and lesser grain borer (Rhysopertha dominica) were found in paddy samples of untreated bags and number of insects increased with time. The germination percentage of grains in untreated bags was significantly higher than the control. It was reduced from 93% to 60-64% and 93% to 82-83% in control and treated bags respectively. During the six months of storage, TGM did not show any significant difference (p=0.05) among different treatments. TMY and HRY resulted significantly (p=0.05) lower values of paddy stored in untreated bags than Zerofly® bags. Use of insecticide incorporated bags can reduce the loss of TMY and HRY of paddy during storage. The study revealed that insecticide treated bags are an appropriate packaging material to protect stored paddy from insect infestations under Sri Lankan conditions.

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1 Introduction

A major loss in post harvest handling of grains occurs during storage due to improper and inadequate storage facilities. Recent studies have revealed that in Sri Lanka, like in other tropical countries, the loss of grains during storage under normal warehouse conditions due to various reasons is about 4-6% and 80% of this amount is due to insect attacks. Improving the proper storage techniques will help in increasing the income of farmers and traders not only by reducing these qualitative and quantitative losses but also through sale of produce during off season at higher prices.

Storing in woven polypropylene sacks is the most popular and commonly used method to store grain. Exposing of grain to insects, rodents, birds and high moisture environment during the storage is unavoidable in Sri Lanka. Currently, application of insecticides and fumigation are the main insect pest control methods practiced in Sri Lanka and storing grains in a hermetic storage structures is another method in controlling insects.

A novel and innovative tool, an insecticide-incorporated polypropylene sacks, has been designed to protect grains and seeds against destructive insect pest infestations during storage. Zerofly® storage bag is a woven polypropylene bag developed by VESTERGAARD S.A., Switzerland for post harvest storage of grains. The active ingredient, Deltamethrin is incorporated into the polypropylene yarns woven together and the active ingredient is released on the surface of the material in a sustained manner so that the commodities stored in the sacks are continuously protected against insect infestation. It has earlier been revealed that deltamethrin incorporated bags provide a powerful killing action against the common insects found in Sri Lanka and the insects were unsuccessful in boring this bag materials.

If people are receptive to new technologies that offer alternative solutions to problems being faced by the grain industry, the food security could be assured by minimizing postharvest grain loss. Therefore, this study was carried out to evaluate the efficacy of insecticide incorporated bags under Sri Lankan conditions.

2 Materials and Methods

2.1 Experimental setup

The study was conducted at the Institute of Post Harvest Technology (IPHT) and at the main warehouse of Paddy Marketing Board (PMB) Anuradhapura, Sri Lanka, where bulk amount of paddy is stored under 29°C ± 4 of ambient temperature and 67% ± 5 of relative humidity. Paddy (long white grain type), harvested from Maha season, 2013/2014 season was purchased and dried to about 14% of moisture content. Then the whole paddy stock was fumigated to ensure that paddy grains were total free from any insect infestations. Paddy sample bagged in Zerofly® sacks were stacked at IPHT and PMB warehouses and as controls, untreated polysack bags were used at both locations together with treated bags. All the treatments and controls were replicated three times for the experiment.

2.2 Data collection and quality analysis

Composite paddy samples were collected before storage and at monthly intervals during the storage period, and were analyzed for moisture content, weight loss due to insect damages, thousand grain mass, germination percentage, total milling yield and head rice yield. Ambient temperature and relative humidity were recorded daily.
Moisture content of paddy was measured according to AOAC method. Insect-damaged kernels were separated from undamaged kernels in a sample of 50g of paddy. Number and weight of damaged and undamaged kernels were also recorded, and mass loss due to insect damage was determined using the following formula;

\[
\text{Mass loss due to insect damage} = \frac{\text{Nu} \times \text{Nd} - \text{Nu} \times \text{D}}{\text{U} \times (\text{Nd} + \text{Nu})} \times 100\%
\]

Where, 
- **Nd** - Number of insect damaged grains
- **D** - Weight of insect damaged grains
- **Nu** - Number of undamaged grains
- **U** - Weight of undamaged grains

Paddy samples obtained were dehulled polished and then milling qualities as total milling yield (TMY) and head rice yield (HRY) were calculated using the following formulae;

\[
\text{Total Milling Yield} = \frac{\text{Weight of polished rice}}{\text{Weight of paddy}} \times 100\%
\]
\[
\text{Head Rice Yield} = \frac{\text{Weight of head rice}}{\text{Weight of polished rice}} \times 100\%
\]

Thousand grains mass (TGM) was obtained by measuring the mass of 1000 paddy grains collected from each sample. To ascertain the germination rate, 100 kernels were germinated on cotton pads soaked with water at ambient temperature. Germinated seeds were counted after 3 days and calculated as a percentage.

2.3 Data analysis
The experimental design was Completely Randomized Design (CRD). Data gathered were analyzed using Analysis of Variance (ANOVA) by Statistical Analysis System (SAS). Differences among treatment means were obtained by Duncan’s multiple range tests at 5% significance level.

3 Results and Discussion

3.1 Grain moisture content (MC)
As shown in Figure 1, the moisture content of paddy grains fluctuated between 13.3 – 14.3% during the storage period. However, any significant difference was not observed among storage bag types proving that moisture migration between grains and atmosphere is almost the same in paddy stored in both treated and conventional polysack bags, irrespective of the location.
3.2 Insect infestations

The loss due to insect damage to paddy grains during six months of storage is presented in the Table 1. According to the results, the level of insect damage increased in controls at both locations while the initial level of insect damage of treated bags remained unchanged during six months of storage. Damage due to insect infestation was significantly higher ($p=0.05$) in paddy samples drawn from untreated bags than that of treated bags during storage. At the end of storage period, the insect damage was significantly higher in PMB warehouse than to IPHT store.

Table 1: Mass loss due to insect damage of paddy grains during the storage

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Initial</th>
<th>1 month</th>
<th>2 months</th>
<th>3 months</th>
<th>4 months</th>
<th>5 months</th>
<th>6 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>0.72a</td>
<td>0.67c</td>
<td>0.80c</td>
<td>0.81c</td>
<td>0.74c</td>
<td>0.69b</td>
<td>0.80c</td>
</tr>
<tr>
<td>T2</td>
<td>0.72a</td>
<td>1.56ab</td>
<td>1.91ab</td>
<td>2.31b</td>
<td>3.93ab</td>
<td>4.21a</td>
<td>4.31b</td>
</tr>
<tr>
<td>T3</td>
<td>0.72a</td>
<td>0.79c</td>
<td>0.79c</td>
<td>0.79c</td>
<td>0.68c</td>
<td>0.71b</td>
<td>0.72c</td>
</tr>
<tr>
<td>T4</td>
<td>0.72a</td>
<td>1.83a</td>
<td>2.56a</td>
<td>3.92a</td>
<td>4.28a</td>
<td>4.93a</td>
<td>5.10a</td>
</tr>
</tbody>
</table>

Values with same letters in columns are not significantly different ($p=0.05$)

T1: Treated bags stored at IPHT warehouse, T2: Control at IPHT, T3: Treated bags stored at PMB warehouse, T4: Control at PMB

In addition, dead insect bodies were observed on outer surface of the insecticide incorporated bags but no live or dead insects were found on untreated bag surface during storage time. Any type of live insects were not present in treated bags during storage while few insect types; mainly rice weevil (Sitophilus oryza) and lesser grain borer (Rhysoperthadominica) were found in paddy samples drawn from untreated bags and number of insects increased with time. Food and Agriculture organization (FAO) in 2014 also reported that these two insect types are common among stored paddy in Sri Lanka. In addition, tropical grain moth (Ephesitia cautella) was observed at PMB warehouse on all paddy stacks except in Zerofly® bags. According to the results and observations, deltamethrin incorporated polypropylene bags can almost prevent insect pest attacks to stored paddy grains. Insecticide incorporated bags show powerful killing action to insects and no insects could not bore through this bag material.
3.3 Change in grain quality parameters

The changes in grain quality parameters; seed germination, thousand grain mass (TGM), total milling yield (TMY) and head rice yield (HRY) are shown in Table 3. As shown in Table 02, the germination percentage of grains stored in insecticide incorporated bags was significantly higher during the whole storage period than that of grains in control. In addition, during six months of period, paddy stored in Zerofly® bags maintained better germination rate compare to the conventional bags. High level of insect infestations usually result lower germination percentage of stored paddy

Table 2: changes in grain quality parameters during the storage period,

<table>
<thead>
<tr>
<th>Grain quality parameters/ Treatments</th>
<th>Storage period (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
</tr>
<tr>
<td>Germination (%)</td>
<td>T1</td>
</tr>
<tr>
<td></td>
<td>T2</td>
</tr>
<tr>
<td></td>
<td>T3</td>
</tr>
<tr>
<td></td>
<td>T4</td>
</tr>
<tr>
<td>TGM (g)</td>
<td>T1</td>
</tr>
<tr>
<td></td>
<td>T2</td>
</tr>
<tr>
<td></td>
<td>T3</td>
</tr>
<tr>
<td></td>
<td>T4</td>
</tr>
<tr>
<td>TMY (%)</td>
<td>T1</td>
</tr>
<tr>
<td></td>
<td>T2</td>
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<tr>
<td></td>
<td>T3</td>
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<tr>
<td></td>
<td>T4</td>
</tr>
<tr>
<td>HRY (%)</td>
<td>T1</td>
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<td></td>
<td>T2</td>
</tr>
<tr>
<td></td>
<td>T3</td>
</tr>
<tr>
<td></td>
<td>T4</td>
</tr>
</tbody>
</table>

Values with same letters in column for each parameter are not significantly different (p=0.05)

T1: Treated bags stored at IPHT warehouse, T2: Control at IPHT, T3: Treated bags stored at PMB warehouse, T4: Control at PMB

During the six months of storage period TGM did not show any significant difference (p=0.05) among different bags and store locations. The moisture content of grains also has resulted a similar pattern.

As presented in table 2, TMY and HRY resulted significantly (p=0.05) lower values of paddy stored in untreated bags than to Zerofly® bags during the storage. Moreover, at the end of storage, these values of control samples which had been stored at PMB warehouse was significantly (p=0.05) lower compared to control sample of IPHT warehouse. Results further indicate that use of insecticide incorporated bags can reduce the loss of TMY and HRY of paddy during the storage. Higher insect infestations directly cause comparative lower TMY and HRY of paddy during storage. In addition, the active ingredient, deltamethrin, is categorised under pyrethroid class, its maximum residue levels on stored commodities are below the most stringent standard globally.

4 Conclusion

Insecticide incorporated polypropylene bags exhibits a complete protection against the insect pests during paddy storage at ambient conditions. In addition, paddy grains stored in treated bags with deltamethrin maintained the germination rate, total milling yield and head rice yield at higher levels. Insecticide incorporated bag type is an appropriate packaging material for long term paddy storage to minimize the post harvest grain loss.

Acknowledgment

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