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Full Length Research Paper

Comparative effectiveness of GrainPro Cocoon™ with traditional storage systems against *Tribolium castaneum* (Hbst.), *Rhyzopertha dominica* (F.) and *Sitophilus oryzae* (L.)

Muhammad Noor ul Ane[1], Muhammad Akbar Zafar Khan[2]*, Muhammad Ishtiaq[3] and Munir Ahmad Shahzad[4]

[1]Department of Agricultural Entomology, University of Agriculture Faisalabad, Punjab, Pakistan.
[2]Entomological Research Institute, Ayub Agricultural Research Institute (AARI), Faisalabad, Punjab, Pakistan.
[3]University College of Agriculture, B. Z. U., Multan, Punjab, Pakistan.
[4]Arid Zone Agriculture Research Institute, P. O. Box No. 15. Bhakkar, Punjab, Pakistan.

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The studies were carried out to evaluate the comparative effectiveness of Grainpro Cocoon™ with traditional storage systems against *Tribolium castaneum*, *Rhyzopertha dominica* and *Sitophilus oryzae*. Four different storage structures (Grainpro Cocoon™, Thick Waterproof Cloth Sheath, Simple Polythene Sheath and control) were used. Each storage structure was tested for three storage periods viz. 5, 10 and 15 days. The results of the trial indicated the cumulative mean mortality of the stored pests (16%) in Grainpro Cocoon™ and was significantly higher ($p < 0.05$) compared with the thick waterproof cloth sheath (4%), simple polythene sheath (8%) and control (0%). Further analysis suggested that the *T. castaneum* was most venerable in the Grainpro Cocoon™ but *R. dominica* was observed to be resistant in Grainpro Cocoon™. The mortality of all tested insects increased with increase in storage period. for example, *T. castaneum* (5%), *R. dominica* (2%) and *S. oryzae* (4%) after 5 days storage increased significantly to 9, 7 and 8% respectively after 15 days storage. The results of the present study suggest that Grainpro Cocoon™ was the most effective hermetic storage structure to control all types of insects for extended storage period.

Key words: *Tribolium castaneum* (Hbst.), *Rhyzopertha dominica* (F.), *Sitophilus oryzae* (L.), GrainPro Cocoon™.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a staple diet in Pakistan. It contributes 13.7% to the value added in agriculture and 3.0% to gross domestic production (Anonymous, 2003). The post harvest losses of wheat grain have been reported to be 10-15% in Pakistan (Ahmad, 1994). Among various contributing factors to these losses insect pests are the most important (Jilani, 1981). *Tribolium castaneum* (Hbst.), *Rhyzopertha dominica* (F.) and *Sitophilus oryzae* (L.) are the most common insect pests of stored grain in Pakistan (Irshad and Talpur, 1993).

*Corresponding author. E-mail: akbarzafarkhan@hotmail.com Tel: 092-041-2656360.

For controlling stored grain insets conventional measures using insecticides are being questioned by environmental agencies and pressure-groups, and the choice of available permissible materials is decreasing. Of the two remaining fumigants in general use, methyl bromide use was phased out in 2005 due to its destructive effect on ozone in the stratosphere and most insects have developed resistance to phosphine.

Navarro (1978) indicated that the use of available storage methods are still expensive yet require adequate infrastructure; hence, it is difficult for small scale farmers to reduce storage losses. Therefore new solution must be socio-economically acceptable.

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Industries have been using Gas tight flexible structures as hermetic storage to control the stored product insects (Navarro et al., 1988; 1994; Navarro et al., 1990).

These structures are manufactured from plastic chambers with an aim to getting a gas-tightness level which enables protection from the biological agents like insects and fungus without significant modified atmosphere or fumigant gas loss (Navarro et al., 1995), and Navarro et al. (1999) termed these structures as Volcani Cubes or GrainPro Cocoon^{TM}.

Unique features in GrainPro Cocoon^{TM} were designed to enable the grain to be loaded and unloaded, with the possibility of periodic removal of limited quantities of grain, after which the openings would be sealed. By these means it was deemed possible to maintain the storability of the grain, without affecting significantly the principle of gas-tightness needed for the control of insect pests.

The aim of the present study is to report on the comparison of application of GrainPro Cocoon^{TM} with traditional storage systems for control of stored grain insects, the second objective was to check the insect that shows maximum resistance and insect that was most susceptible to hermetic storage and thirdly, to check the technology of hermetic control of stored grain insect pests and its application under the local conditions of Pakistans.

MATERIALS AND METHODS

T. castaneum (Hbst.), *R. dominica* (F.) and *S. oryzae* (L.) were reared for one generation in order to obtain homogeneous progeny. Adults were placed in an incubator at 30 ± 2°C whereas relative humidity was maintained at 65 ± 5%. Relative humidity was maintained inside the incubator by placing an open tray filled with saturated solution of $NaNO_3$. Rearing media consisted of flour: corn meal diet (1:1 w/w). The rearing media was poured into one liter capacity jars covered with muslin cloth. A piece of filter paper was also placed in each jar to provide resting place for insects. For this purpose, 50 adults of each will be released in the plastic jars containing 200 g of sterilized wheat. After 3 days the adults were separated from jars by sieving. After 28-30 days first peak will be emerged which were pure homogenous population.

A GrainPro Cocoon^{TM} of 10 ton capacity was used. The storage cube was manufactured by Haogenplast Ltd, Israel. It comprised a lower floor-wall section and an upper roof-wall section. The lower floor-wall section was made of white flexible (0.83 mm-thick) polyvinyl chloride (PVC) sheeting while the top cover was made of white nylon reinforced chlorinated polyethylene (CPE) plastic sheet which provided protection from degradation by UV radiation. The lower floor-wall and the upper roof wall are sealed together by a gas proof zipper. The zippers are covered by a protective over-flap (Donahaye and Navarro, 1989). The Cocoon was loaded with 199 plastic bags each weighing 50 kg (total 9950 kg) of wheat grain. A second stack of 199 bags of wheat grains was covered with thick waterproof cloth sheath. A third stack of 199 bags of wheat grains was covered with simple polythene sheath, fourth stack of 199 bags of wheat grain without any cover to retain heat was designed as the control. Newly-harvested locally grown wheat, bagged in 50 kg plastic bags was provided by Punjab Food Department.

Insect bioassay receptacles were prepared and placed among the bags inside the 4 different storage systems at the start of the experiment. Bioassay receptacles were consisted of ventilated jars containing insect pests that infest wheat grains: *T. castaneum* (Hbst.), *R. dominica* (F.) and *S. oryzae* (L.) adults. One jar containing 20 *T. castanium* (Hbst.), one containing 20 *R. dominica* (F.) and one containing 20 *S. oryzae* (L.) adults were placed at three different locations within the stack of bags containing wheat grains covered by GrainPro Cocoon^{TM} and similarly, 3 separate jars were placed in three different locations in each storage system. Then we removed these jars from the stacks of each storage systems after 5, 10 and 15 days storage periods from the start of the test. Survivals of these insects were compared with those of insects held in without any cover wheat grain stock which is designed as control.

At the end of storage period, storage structures were examined and jars were opened. The adults of *T. castaneum*, *R. dominica* and *S. oryzae* were separated from grains and mortality was assessed.

The experiment was replicated three times. The collected data were analyzed statistically by analysis of variance and least significance difference test (Steel and Torrie, 1980).

RESULTS

In Table 1, the data of analysis show that, storage structures (A), storage periods (B), and interaction between storage structures and storage periods had high significant effect on the mortality of *T. castaneum, R. dominica* and S*. oryzae.*

Maximum mean percentage mortality of *T. castaneum* (15.67%) was observed on GrainPro Cocoon^{TM}, which was followed by simple polythene sheath (7.889%), thick waterproof cloth sheath (3.889%), while no mortality was observed in the control. Fifteen (15) days storage period gave maximum mortality (8.750%), while no mortality was observed after 5 days storage, which differed significantly from 10 days storage period (7.167%) (Table 1).

Mean mortality in GrainPro Cocoon^{TM} was higher (9.44%) than thick waterproof cloth sheath, simple polythene sheath and control which was 2.333, 4.778 and 0.00% respectively against *R. dominica*. Fifteen (15) days storage period gave maximum mortality (6.583%) and minimum mortality (2.250%) was observed in 5 days storage period.

Comparison of means for storage structures against *S. oryzae* shows that GrainPro Cocoon^{TM} gave maximum

Table 1. Comparison of mean mortalities for storage structures and storage periods against *T. castaneum, R. dominica* and *S. oryzae*.

Tested stored grain pest	Storage structure (A)				Storage period in days (B)		
	GrainPro Cocoon™ (A1)	Thick water proof cloth sheath (A2)	Simple polythene sheath (A3)	Control (A4)	5 (B1)	10 (B2)	15 (B3)
T. castaneum	15.67[a]	3.889[c]	7.889[b]	0.000[d]	4.667[c]	7.167[b]	8.750[a]
R. dominica	9.444[a]	2.333[c]	4.778[b]	0.000[d]	2.250[c]	3.583[b]	6.583[a]
S. oryzae	15.33[a]	3.667[c]	7.667[b]	0.000[d]	4.500[c]	7.167[b]	8.333[a]

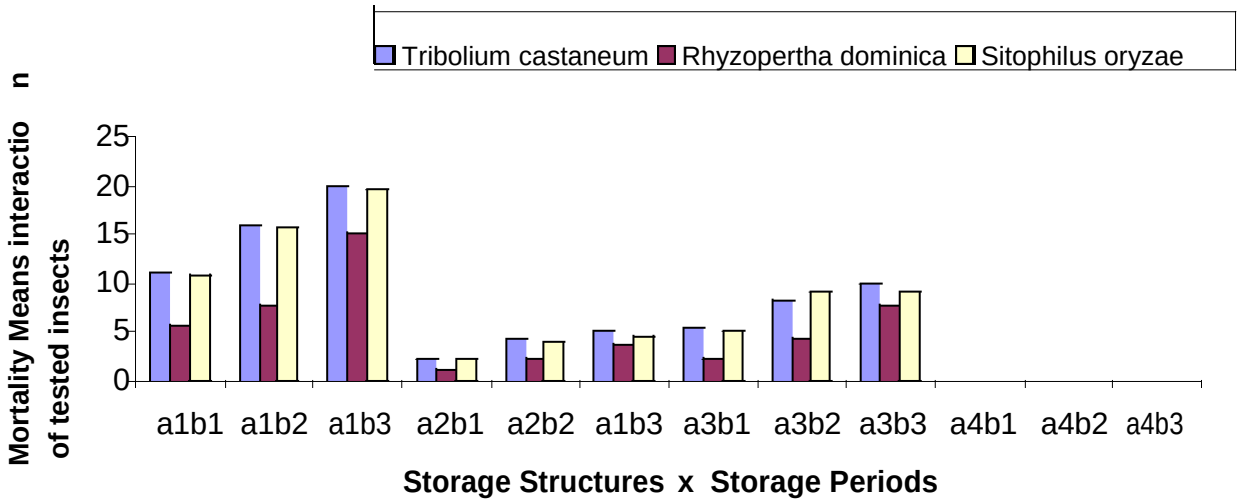

Figure 1. Comparison of Mortality Means interaction of *T. castaneum, R. dominica* and *S. oryzae* for Storage structures × Storage periods.

mean percentage mortality (15.33%), followed by simple polythene sheath (7.667%) and thick water proof cloth sheath (3.667%). Whereas, in the control, number of insects tested, remain unchanged. Comparison of means for storage periods against *S. oryzae* showed maximum mortality (8.333%), which was observed after 15 days storage period, while the minimum mortality was found after 5 days storage period.

Figure 1 shows that, GrainPro Cocoon™ after 15 days storage had the maximum mortality with *T. castaneum*. Minimum mean mortality (5.333%) occurred on 5 days storage period with simple polythene sheath. The data reveals that maximum mortality of *R. dominica* were observed on 15 days storage period with GrainPro Cocoon™ and also shows that GrainPro Cocoon™ with 15 days storage period gives maximum mortality of *S. oryzae*. The results also showed that *R. dominica* has maximum resistance to GrainPro Cocoon™. In contrast, *S. oryzae* was found most susceptible against the tested insects.

DISCUSSION

In the present investigation, it was found that GrainPro Cocoon™ is effective for the control of *T. castaneum*, *R. dominica* and *S. oryzae.* This suggests that GrainPro Cocoon™ prevented air from entering or leaving, which led to an increase in the level of carbon dioxide content of inter-granular atmosphere. This occurred due to low oxygen content as a result of the respiratory metabolism of insects, moulds and grains. The results are supported by Rupollo et al. (2004), Finkelman et al. (2002); Emekci et al. (2002) and Aliniazee (1971).

The results of this study also differ from the findings of Donahaye and Navarro (1999) and Seck et al. (1996). These scientists found that hermetic storage killed all tested insects. But in our study *R. dominica* showed maximum resistance. Our study is also similar with the findings of Calderon and Navarro (1980), who found that, *R. dominica* eggs were more tolerant than *T. castaneum* eggs even up to the above treatments. Our study is also similar to the findings of Hulasare et al. (2002) who demonstrated that, *R. dominica* is the most tolerant species tested against low pressure.

In the present investigation it was also found that GrainPro Cocoon™ is effective in killing the stored grain insect pest in 15 days. The reason is due to increasing level of carbon dioxide and the lowering of oxygen content with the passage of time. These results are

supported by Paster et al. (1990), Navarro and Donahaye (1986), Damcevski et al. (1997), Edward and Cuff (1981) and Oxley et al. (1963).

The overall result of this study revealed that, GrainPro Cocoon^{TM} is best compared to the other traditional storage system and *R. dominica* showed maximum resistance among tested insects.

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