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STUDY ON HERMETICALLY SEALED STORAGE SYSTEM FOR RICE SEEDS

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ABSTRACT

Two experiments, one small and one large scale, on hermetically sealed storage systems had been conducted for one year at the Cuu long Delta Rice Research Institute since 3 February 2004. The objectives of these experiments are: (i) to compare the performance of IRRI Super bag manufactured by GrainPro Inc in Israel and Vietnamese bag and (ii) to evaluate the effects of different methods of storage on insect infestation and rice seed longevity. Results revealed that a number of insects are equal in IRRI and VN bag. Hermetic storage methods with or without insecticides are better than traditional method of aerobic storage of farmers in terms of insect population. The germination percentages (G.P.) under IRRI and VN bags are similar at three and six months after storage. However, at 9- and 12-month storage, IRRI bag was superior to VN bag statistically. Treatment of Unaerobic+ Mosfly gave the same performance with that of Unaerobic+Basudin. The average G.P. data of these two treatments observed at 3, 6, 9 and 12 months are 95.4; 90.8; 71.3 and 27.5%, respectively. The method of hermetic storage alone without chemical gave the G.P. of: 91.7; 87.5; 60.8 and 17.5% and lower than that of the treatment Unaerobic+ Basudin, statistically. The worst method was farmers' tradition of aerobic storage. The corresponding data of G.P. were 87.5; 77.5; 46.7 and 5.0%. The results of large scale testing with 20 kg of rice seeds showed that G.P. continued to maintain at 85.75% after one year two months and three days under undisturbed hermetic storage.

Key words: aerobic, longevity, hermetic storage, rice seed.

INTRODUCTION

From pre-historic times until present day, the underground storage in pits as a traditional method that is frequently sufficient air-tight to enable insects and other aerobic organisms in the grain-mass to reduce oxygen concentration below the level permitting insect development. During the World War II, prolonged storage of grain surpluses consisted of below and above ground concrete lined trenches covered with flexible roofs was established in Argentina. Latter attempts at achieving hermetic storage were the Cyprus bins constructed in the 1950s. These consisted of concrete lined conical pits surmounted by domed concrete-shell roofs. They were successfully used under hermetic conditions for a number of years. Improved versions of these structures were later constructed in Kenya for hermetic storage of national grain reserve. In Australia the modified atmosphere storage was done to improve fumigations but not for hermetic storage as such. In China, the "Triple Low" grain preservation regime consists of reduced O_2 concentration, phosphine and low temperature treatments. In the early 1970, above-ground structures were designed in England for emergency storage using flexible plastic liners supported by a weld mesh frame. These liners were made of butyl rubber. However, under tropical and sub-tropical climates the liners were found to deteriorate and gas permeability increased to a level where the liners could no longer be used for hermetic storage. In Israel, the manufacture of PVC liners that conform to pre-requisite specifications of durability to climate, gas-permeability, and physical properties, enabled the development of four storage systems based on the hermetic principle. These are: bunker storage, flexible silos, volcanic cubes or GrainPro cocoons and Grainsafe. The Grainsafe technology provides the hermetic storage for subsistence farmers lies in the need to provide an easily sealable low-cost container of about a ton or even

smaller capacity. Recently, the GrainPro Super Bags are intended for resealable safe storage of dry seeds or commodities in reusable or disposable bags in sizes from 1 to 50 kg capacity. This consists of transparent multi-layer with gas barrier between two layers of poly-ethylene of 0.078 mm thick. The International Rice Research Institute transfers this technology from Israel to rice farmers under the name of IRRI Super Bags. The IRRI Super Bags were brought to the Cuu Long Delta Rice Research Institute for testing in November 2004 through the Agricultural Engineering Unit of IRRI. The technology is based on the principle of hermetic storage. The lower the grain moisture content and corresponding inter-granular humidity, the higher the mortality, due to the desiccation effect on insects caused by low O_2 or elevated CO_2 concentrations (Navarro 1978). The bio-accumulation of CO_2 and thus depletion of O_2 in the intergranular space of the commodity through the respiration of pests and microorganisms prevents arthropod pest development and minimizes their damage to the commodity (Navarro et al. 1994). Seed viability was maintained for a much longer period from 6 to 12 months (Rickman 2004). The objective of this research is to find out the performance of hermetically sealed grain storage systems in keeping rice seeds in Vietnamese situation.

MATERIALS AND METHODS

1. Materials

IRRI Super bags were brought into Vietnam in November 2004 from the Agricultural Engineering Unit of IRRI. This kind of bags has been manufactured by the Israel-based factory of the GrainPro Inc. Some major characteristics of this bag are: size 75 cm wide x 135 mm long, weight 100 grams /m^2, thickness 0.078 mm, elongation 600%, haze 15%, clarity 85%, oxygen permeability 55 cc/m^2/day, water vapor 8g/m^2/day. Materials used to make Vietnamese (VN) bag are the popular poly-ethylene sheet in the market with the same thickness of 0.078mm. The size of bags in the small scale testing is: 18 cm long and 10 cm wide containing 120 grams of rice seeds.

2. Methods (i) Small scale experimentation: A slit plot design was used in this experiment. Two main plot treatments are: M1 [IRRI bag] and M2 [VN bag]. Four sub- plot treatments are : S1[Aerobic], farmers' tradition of seed storage, oxygen and water vapour move freely between inside and outside the bag; S2 [Unaerobic], hermetically sealed storage without insecticide, bag was tired strongly by rubber band; S3 [Unaerobic+Mosfly insecticide], hermetically sealed storage with Mosfly insecticide, one small piece (0.25 grams) of Mosfly coil contained in a tiny plastic bag (2cm x 2cm) was put inside treatment bag; S4 [Unaerobic + Basudin insecticide], a small amount (0.12 grams) of Basudin granule contained in a tiny plastic bag (2cm x 2cm) was put inside treatment bag. Rice variety OMCS2000 was used. The grain moisture content of 12% and the germination percentage (G.P.) of 100 % were measured at the beginning of experimentation on 3 February 2005. The germination percentage and the number of insects per bag were counted at 3, 6, 9 and 12 months after storage. The data on germination percentage were transformed by arsine and the data on the number of insects were transformed by the square root of x+0.5 before analysis by IRRISTAT program.

(ii) Large scale testing: 20 kg of rice seeds cv. OMCS2000 was contained in a IRRI super bag for 14 months under hermetically sealed condition. The germination percentages were tested 20 times in Petri dishes with 20 seeds each before and after the experimentation.

RESULTS AND DISCUSSION

1. Results of small scale testing

Germination percentage

The germination percentage of rice seeds at 3, 6, 9 and 12 months after storage have been presented in the table 1.

Table 1: Germination percentage (%) of rice seeds as affected by treatments

	After 3 months		After 6 months		After 9 months		After 12 months	
	O(*)	T(*)	O	T	O	T	O	T
A) Kind of bag								
M1) IRRI bag	95.0	80.3a (**)	91.3	75.4a	71.3	58.5a	31.3	32.6a
M2) VN bag	90.0	72.7a	82.1	65.3a	53.8	47.2b	7.5	13.4 b
CV (%)		13.2		8.7		7.7		35.9
B) Methods of storage								
S1) Aerobic	87.5	69.4b	77.5	61.8 c	46.7	43.1 c	5.0	10.5 b
S2) Unaerobic	91.7	74.8ab	87.5	71.2 b	60.8	51.5 b	17.5	24.0 a
S3) Unaerobic+ Mosfly	95.0	79.7a	88.3	70.4 b	68.3	56.6 a	21.7	24.8 a
S4) Unaerobic+ Basudin	95.8	81.9 a	93.3	77.9 a	74.2	60.2 a	33.3	32.8 a
CV (%)		7.8		6.3		7.3		32.2

Remark: (*) O= Original data; T= Arcsin transformed data.(**) Data in a column followed with the same letter are not different significantly by Duncan Multiple Range Test.

The germination percentages of rice seeds tended to be different under two kinds of bags. At 3 months after storage, the G.P. in IRRI bag was 95% while in VN bag 90%. Similarly, at 6- month storage, the corresponding data were 91.3% and 82.1%. However, these differences were not significant. At 9-month storage, IRRI bag was superior to VN bag statistically in terms of maintaining the better longevity of rice seeds. The G.P. under IRRI and VN at this stage are 71.3% and 53.8%, respectively. Regarding the methods of storage, there was a clear difference amongst treatments at the beginning of storage at three months. The G.P. under S2 [Unaerobic] (91.7%); S3 [Unaerobic+Mosfly] (95%) and S4 [Unaerobic+Basudin] (95.85%) are equal statistically. However, two treatments of S3 [Unaerobic+Mosfly] and S4 [Unaerobic + Basudin] are significantly higher than that of S1 [Aerobic] (87.5%). At sixth month, the highest G.P. was under S4 [Unaerobic+Basudin] which was superior to all the rest of treatments. S2 [Unaerobic] (87.5%) and S3 [Unaerobic+Mosfly] (88.3%) exhibited the same G.P. but they were higher than that of S1 [Aerobic] (77.5%) significantly. However, the trend in 9-month storage is little different with that of 6-month storage. Treatments S3 [Unaerobic +Mosfly] (68.3%) and S4 [Unaerobic+ Basudin] (74.2%) were similar in G.P but higher than those in the rest of two treatments. At this stage, the treatment S2 [Unaerobic](60.8%) continued to have higher seed longevity than the check of aerobic storage (46.7%). That was the average data of the two kinds of IRRI and VN bags. In case of IRRI bag alone, the G.P. is much higher. In S4 [Unaerobic+Basudin] of IRRI bag, the G.P. continues to achieve 86.5% after 9 months of hermetically sealed storage. This opens a bright scope of using rice seeds harvested in Winter-Spring season (February-March) to supply seeds for the next Winter-Spring season which normally is sown in November - December every year. In the meantime, the stored seeds can serve for any rice cropping season such as Summer-Autumn and Autumn-Winter seasons with less than 9 months storage.

Insect population

Some species of insects attacking rice seeds were observed during the process of experimentation. However, only the lesser grain borer (*Rhizopertha dominica*) was counted at different stages of storage. The data of the population of this insect have been presented in Table 2, Figure 1 and Figure 2.The number of insects tended to increase in VN bag as compared to that of IRRI bag but the difference had not reached the level of significance at all four stages of observation. The average number of insects per 120 grams of rice seeds in IRRI bag at 3, 6, 9 and 12 months after storage are 6.3; 7.3; 23.2 and 14

insects. The data in VN bag were 8.5; 14.8; 37.8 and 17.2 insects, respectively. The number of insects in rice seeds was strongly affected by different methods of storage. At 3-month storage, the number of insects was highest under treatment S1 [Aerobic] (21.5 insects /bag) and higher than those in all the rest of treatments. The corresponding data under treatments S2 [Unaerobic]; S3 [Unaerobic+Mosfly]; S4 [Unaerobic+ Basudin] were 4.5; 3.5 and zero insects per bag. There was a little difference at 6 months after storage. Two treatments of hermetially sealed storage in combination with insecticides S3 [Unaerobic + Mosfly] and S4 [Unaerobic+ Basudin] had the same number of insects (0.8 insects per bag) and lower than the rest of two treatments. The treatment S2 [Unaerobic] (2.2 insects per bag) had lower number of insects per bag as compared to that of S1 [Aerobic] check (39.2 insects / bag). The S4 [Unaerobic+ Basudin] (2.3 insects /bag) continued to be superior to all the rest of three treatments in terms of insect population reduction. The treatment S2 [Unaerobic] (12.5 insects /bag) was equal with that of S3 [Unaerobic+ Mosfly] (9.7 insects /bag) statistically. The highest number of insects per bag is under S1 [Aerobic] treatment with 94.7 insects per bag which was equal with 789 insects per one kg of rice seeds. At 12-month stage, the population of insects tended to reduce gradually as compared to that at 9 months of storage even in the check treatment of S1 [Aerobic]. This may be due to the spoiled environment caused by insects themselves and the degradation of rice seeds. The numbers of insects in all three hermetically sealed treatments either with or without insecticides were equal statistically. These are 4.7; 0.5 and 0.5 insects / bag in S2; S3 and S4, respectively. All the three were lower than that of the aerobic check treatment (56.7 insects /bag).

Table 2: Population of the lesser grain borer (No. of insects / 120 grams of seeds) as affetcted by treatments.

Treatments	After 3 months		After 6 months		After 9 months		After12 months	
	O(*)	T(*)	O	T	O	T	O	T
A) Kind of bag								
M1) IRRI bag	6.3	2.0 a (**)	7.3	2.1 a	23.2	3.3 a	14.0	2.5 a
M2) VN bag	8.5	2.5 a	14.8	2.9 a	37.8	5.3 a	17.2	3.1 a
CV(%)		42.8		21.4		30.6		20.6
B) Methods of storage								
S1) Aerobic	21.5	4.7 a	39.2	6.1 a	94.7	9.7 a	56.7	7.5 a
S2) Unaerobic	4.5	1.9 b	4.7	2.2 b	15.2	3.3 b	4.7	1.9 b
S3) Unaerobic + Mosfly	3.5	1.7 bc	0.2	0.8 c	9.7	2.9 b	0.5	0.9 b
S4) Unaerobic + Basudin	0.0	0.7 c	0.2	0.8 c	2.3	1.4 c	0.5	0.9 b
CV(%)		39.0		25.6		23.8		32.3

Remark: (*) O= Original data; T=Transformed data by square root of x+0.5.(**) Data in a column followed by the same letter are not different significantly by Duncan Multiply Range Test.

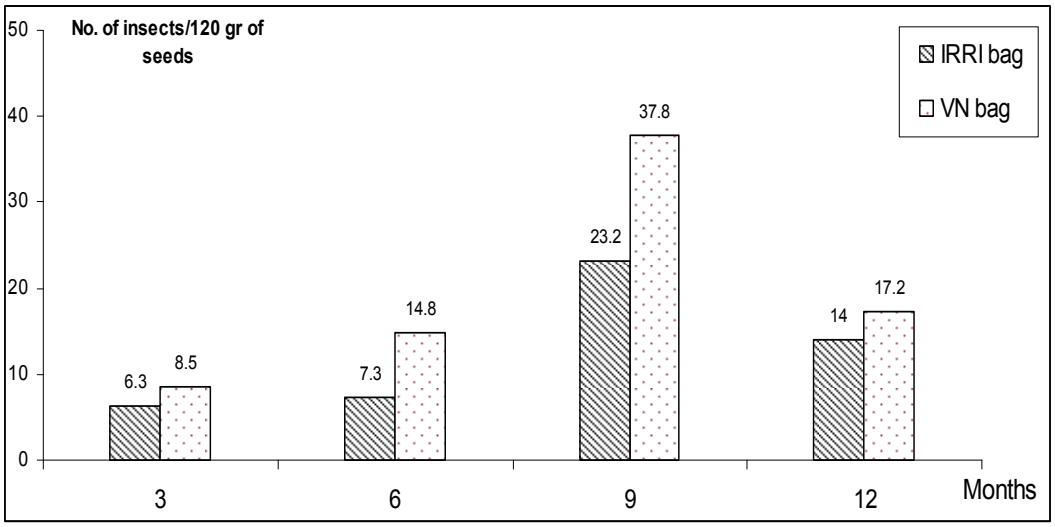

Figure 1: Effects of kinds of bag on insect population

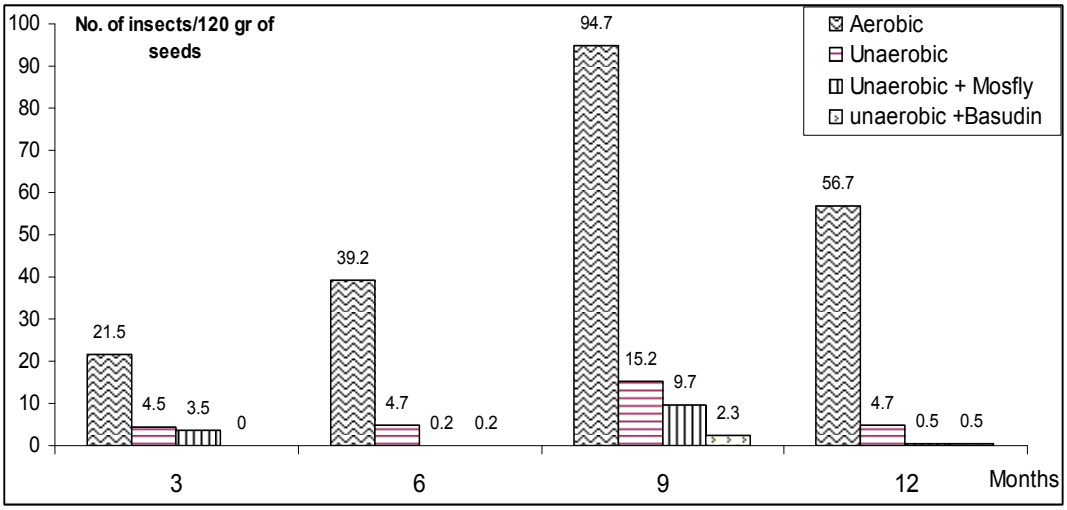

Figure 2: Effects of methods of storage on insect population

2. Result of large scale testing

A large scale testing was conducted at CLRRI in 22 December 2004 with the IRRI Super bag. The size of this bag is 75 cm x 135 cm. Seeds for testing were received from the stock of certified seeds in the store of the CLRRI. These OMCS2000 seeds were stored in 9 November 2004. Seeds were started to test for the hermetically sealed storage without any chemical in 22 December 2004 after 43 days under aerobic condition. Its grain moisture content was 12%. Before starting the experiment, germination percentage of the seeds was examined with 20 replications by a standardized method using Petri dishes. The testing bag was opened and the G.P. was examined in 25 February 2006. They are presented in Table 3.

Table 3: Germination percentage (%) of rice seeds in large scale hermetically sealed storage.

No.	G.P.(%) before hermetically sealed storage	G.P.(%) after hermetically sealed storage
1	100	100
2	100	95
3	100	85
4	95	85
5	100	90
6	100	80
7	95	90
8	100	90
9	100	80
10	95	90
11	100	80
12	100	95
13	95	90
14	100	65
15	100	85
16	100	95
17	95	85
18	100	85
19	100	75
20	100	75
Average	98.75	85.75

The germination percentage remained very high at 85.75% after one year two months and three days of hermetically sealed storage. If calculation was made from the beginning of aerobic storage in CLRRI warehouse (9 November 2004), the total duration of storage was one year three months and 16 days. According to the Vietnamese standard, certified seeds of rice can be used for production with the germination percentage higher than 85%. This result is very promising to ensure the quality of rice seeds for any season whole year round.

CONCLUSION AND SUGGESTION

The germination percentage in VN bag tended to be lower than that of IRRI bag observed at three and six months after storage but the differences were not statistically significant. However, at 9 and 12 months after storage, IRRI bag shows better performance than VN bag significantly. At 9- month storage, the G.P. in IRRI was 71.3% as compared to 53.8% in VN bag. The corresponding data after 12 months were 31.3 and 7.5%, respectively. Regarding the methods of storage, hermetically sealed storage system using poly-ethylene bag reduced insect population in the stock of rice seeds and increases germination percentage of rice seeds observed at 3, 6, 9 and 12 month-storage as compared to the traditional method of aerobic storage by farmers. In aerobic condition the G.P. are 87.5%; 77.5%; 46.7% and 5.0% after 3, 6, 9 and 12 month-storage, respectively. The performances in strengthening the seed longevity in unaerobic condition are much better. In the unaerobic condition without insecticide, the G.Ps. were 91.7; 87.5; 60.8 and 17.5 %. The corresponding data under [Unaerobic + Mosfly] treatments are 95; 88.3; 68.3 and 21.7 %. In [Unaerobic+ Basudin] treatments, the G.Ps. were 95.8; 93.3; 74.2 and 33.3%, respectively. In large scale testing of 20kg of rice seeds, the G.P. continued to maintain very high of 85.75% after one year 2 months and 3 days under hermetically sealed condition. It is suggested that further studies are needed to find out the reasons causing the G.P. differences in small and large scale testing raised by this research. More studies need to be done for achieving the target goal

of reserving rice seeds with more than 85% G.P. after 12-month storage to serve for any cropping season and for any situation including re-sowing after natural disaster.

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Nghiên cứu tồn trữ hạt giống lúa bằng túi yếm khí

Các nước đang phát triển không đủ điều kiện trang bị được hệ thống kho lạnh hiện đại tập trung để tồn trữ lâu dài hạt giống cây trồng, trong đó có cả hạt giống lúa. Một kỹ thuật khả thi để tồn trữ hạt giống trong điều kiện nhiệt độ và ẩm độ bình thường là sử dụng túi yếm khí. Thí nghiệm trên diện hẹp chính qui, có lập lại và thí nghiệm trên diện rộng đã được tiến hành tại Viện lúa đồng bằng sông Cửu long trong hơn một năm qua kể từ ngày 3 tháng 2 năm 2004. Mục đích của nghiên cứu này là: (i) Đánh giá chất lượng bao poly-ethylene Việt nam (VN) so với bao IRRI sản xuất tại Israel; và (ii) So sánh một số biện pháp tồn trữ khác nhau đối với quần thể côn trùng gây hại trên hạt lúa giống và tỷ lệ nẩy mầm của hạt qua thời gian tồn trữ. Kết quả nghiên cứu cho thấy mật số côn trùng trong bao IRRI và VN tương tự nhau. Trong bao IRRI có 6.3; 7.3; 23.2 và 14 con/120 g. hạt. Số liệu tương ứng ở bao VN là 8.5; 14.8; 37.8 và 17.2 con / 120 g. hạt. Các nghiêm thức tồn trữ yếm khí đơn thuần hoặc có kết hợp với thuốc sát trùng đều giảm mật số côn trùng có ý nghĩa thống kê so với tập quán tồn trữ hảo khí của nông dân. Số liệu trung bình của côn trùng tại ba nghiệm thức yếm khí quan sát lúc 3; 6; 9 và 12 tháng tồn trữ là 2.7; 1.7; 9.1 và 1.9 con / 120 g. hạt. Số liệu ở nghiệm thức hảo khí cao hơn rất nhiều và tương ứng là 21.5; 39.7; 94.7 và 56.7 con /120 g. hạt. Bao IRRI và bao VN cho tỷ lệ nẩy mầm của hạt tương tự nhau sau 3 đến 6 tháng tồn trữ. Tuy nhiên nếu tồn trữ dài hơn từ 9 đến 12 tháng thì bao IRRI cho kết quả ưu việt hơn. Tồn trữ yếm khí có kết hợp với nhang xông muỗi Mosfly cho kết quả tương tự với kết hợp thuốc sát trùng hạt Basudin. Số liệu trung bình về tỷ lệ này mầm của hai nghiên thức này quan sát lúc 3, 6, 9 và 12 tháng tồn trữ là 95.4; 90.8; 71.3 và 27.5%. Tồn trữ yếm khí đơn thuần đạt 91.7; 87.5; 60.8; 17.5% và thấp hơn so với nghiệm thức yếm khí có kết hợp với Basudin. Tồn trữ hảo khí theo tập quán nông dân cho kết quả kém nhất và thấp hơn tất cả các phương thức tồn trữ yếm khí. Số liệu tỷ lệ nẩy mầm tương ứng là: 87.5; 77.5; 46.7 và 5.0%. Kết quả thí nghiệm diện rộng dùng tuí IRRI chứa 20 kg lúa giống thì tỷ lệ nẩy mầm vẫn còn đạt 85.75% sau một năm hai tháng ba ngày tồn trữ yếm khí. Kết quả này rất triển vọng và cần được nghiên cứu chi tiết hơn trong tương lai để sớm ứng dụng đại trà phục vụ sản xuất.