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Preservation of Mestizo 1 (PSB Rc72H) seeds using hermetic and low temperature storage technologies

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Abstract

The technical feasibility and cost effectiveness of Hermetic Storage (HS) Technology using Volcani Cubes or GrainPro Cocoons as an alternative storage in preserving the quality of registered PSB Rc72H (Mestizo 1) hybrid paddy seeds were assessed. It was compared with other locally used storage technologies, namely: Cold Room Storage (CRS) with 13.0-15.0 °C and 40-50 % relative humidity (r.h.); Air-conditioned Room Storage (ACRS) with 27.0 °C and = 60 % r.h.; and Conventional Storage (CTRL) with 28.0-38.0 °C; 60-89 % r.h. Storage trials of 3, 6 and 9- month duration were carried-out. Six piles measuring 2.95m x 1.70m x 1.50m in length, width and height, respectively were built for observation. Each pile contained 200 bags (20 kg/bag) of one-month old Mestizo 1 hybrid paddy seeds with 9.55-10.45 % moisture content (m.c.). Samples gathered at the beginning and end of storage trials were analyzed based on the following parameters: germination rate, moisture content, insect density, and weight loss. Cost effectiveness per bag was estimated based on the cost of investment and fixed and variable costs of operating expenses during storage. Germination rate of seeds kept in HS for six months was comparable with those in CRS and significantly higher than those in ACRS. However, the reverse was observed after nine

months. The germination rate of conventionally stored seeds was maintained at 85 % for three months only. Of the various storage technologies observed, HS was the most effective in controlling insect infestation and reducing weight loss. Ranking of technologies from most to least cost effective was CTRL > HS > ACRS > CRS if storage was for 3 months, and HS > CTRL > ACRS > CRS if storage period was extended.

Key words: Mestizo 1; Hermetic Storage; Cold Room Storage; Air-conditioned Room Storage; Conventional Storage.

Introduction

The Philippine government through the Department of Agriculture is aggressively promoting and implementing its “Hybrid Rice Commercialization Program” (HRCP) to make the country self-sufficient in rice at the soonest possible time. The hybrid rice variety recommended for massive planting nationwide is the locally developed PSB Rc72H known as “Mestizo 1” (Redoña et al., 1998). However, Mestizo 1 seeds are more vulnerable to the various factors of deterioration like insects, fungi, temperature, relative humidity, and physiological changes than inbred seeds. Therefore, the program must be complemented with adequate

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storage technologies to preserve the quality of hybrid paddy seeds for prolonged periods.

Good quality Mestizo 1 hybrid paddy seeds are largely produced during the dry cropping season. These are usually stored for periods of up to 9 months in time for planting in the succeeding dry cropping season. Therefore, long term preservation of the seeds is necessary. The storage technologies that are presently being employed are the low temperature storage technologies such as the Cold Room and Air-conditioned Room, and the Conventional Storage Technique. Conventional storage involves the piling of bagged seeds on pallets inside the warehouse and protecting these from pests' infestation by maintaining high degree of hygiene and sanitation, and through the integrated use of insecticides. Since, the low temperature technologies are dependent on electricity which is very expensive and the conventional storage is inadequate in preserving the quality of Mestizo 1 paddy seeds during long term storage, the use of "hermetic, gastight or airtight" storage technology as storage option was investigated. The concept of the hermetic storage technology is the bio-generation of an oxygen-deficient and carbon dioxide-enriched atmosphere in a sealed storage ecosystem. The synergistic effect of the concomitant oxygen depletion and carbon dioxide accumulation makes aerobic respiration no longer possible. This environment could control insect infestations but preserve the quality of grains (Calderon and Navarro, 1980). The practical application of hermetic storage using Volcani Cubes or GrainPro Cocoons as a storage option for preserving Mestizo 1 hybrid paddy seeds was intensively investigated and compared with the other currently used storage technologies.

Materials and methods

Seed variety tested, duration, and location of storage trials

Stocks of one month old Mestizo 1 hybrid paddy seeds harvested in April-May 2004 dry

season crops from adjacent farms in Tabuk, Kalinga in Luzon were used in the trials. Seeds were sun dried to a moisture content of 9.55-10.45 %. These were bagged in 20 kg capacity Kraft bags, a closely woven polypropylene plastic sack with an internal polyethylene plastic liner. Storage trials of 3, 6, and 9 months durations were carried out at the storage facilities of the Philippine Rice Research Institute (PhilRice), Maligaya, Science City of Munoz, Nueva Ecija.

Storage technologies observed and experimental set-up

The piles built to demonstrate the effect of the storage technologies had a uniform dimension of 2.95 m x 1.70 m x 1.50 m in length, width and height, respectively. Each pile comprised 200 bags of Mestizo 1 hybrid paddy seeds of 20 kg each bag. The storage technologies studied and their set-up were as follows:

a) Hermetic Storage (HS) – Three Volcani Cubes or GrainPro Cocoons made of flexible Polyvinyl Chloride (PVC) plastic liner (5 MT capacity) were set-up inside a warehouse for hermetic storage of Mestizo 1 hybrid paddy seeds. Bagged seeds were directly stacked or piled on the lower section of the Cubes and when the desired height was reached, these were covered with the upper section of the Cube. Thereafter, the lower and upper sections were pulled together closely then zipped with a gastight multiple tongue and groove zipper respectively sewn at their open ends. Three cubes were randomly assigned for destructive sampling at 3, 6, and 9 months, respectively.

b) Cold Room Storage (CRS) – One pile of bagged seeds was constructed on wooden pallets inside a Cold Storage Room for observation and sampling at the specified periods during the storage trials. The Cold Room Storage is a walk-in type constructed inside one of the warehouses of PhilRice. It has a dimension of 9.0 m x 6.0 m x 3.0 m (LWH) and a capacity of 1,000 bags each containing 20 kg of seeds. The cold room has a digital room temperature and r.h. recorder programmed at 13-15 °C and 40-50 %,

respectively with an inner and outer precision formed metal skin. Its walls and roof have a full 4-inches foam-in-place insulation and thermal breaks that prevented condensation and heat transfer between compartments.

c) Air-conditioned Room Storage (ACRS) - One pile of bagged seeds was constructed on wooden pallets inside an air-conditioned room, 12.0 m x 6.0 m x 5.0 m LWH, for observation and sampling during the storage trials. The warehouse had a total capacity of 1,500 bags with 20 kg seeds each. It was equipped with two units of 2-hp window type air-conditioner that were alternately operated to maintain a temperature of 25-27 °C. An r.h. of = 60 % was maintained inside the room with a portable 360 watt dehumidifying equipment.

d) Conventional storage (CTRL) - One pile of bagged seeds, also built on wooden pallets was used for observation and sampling at the specified periods. This was stored inside a big warehouse with a dimension of 30.0 m x 30.0 m x 10.0 m (LWH) and with a maximum capacity of 10,000 bags containing 20 kg seeds each. The warehouse has concrete walls and galvanized iron roofs. It is ventilated with two units of exhaust fan. The temperature and r.h. inside the warehouse ranged from 28- 38 °C and 60- 89 %, respectively.

All piles or stacks built for the storage trials were provided with a data logger to record temperature and r.h. The data loggers were installed inside a marked bag at the core of the top most layer of each pile. The ambient temperature and r.h. inside the warehouses where the trials were conducted were likewise recorded with data loggers. A gas inlet/valve was attached to the Cocoons or Cubes to monitor oxygen (O₂) concentration inside the structure daily for the first 15 days then at 2 weeks interval thereafter using a GrainPro oxygen tester.

Sampling Procedure

Each experimental pile consisted of 10 layers of bagged seeds which were divided into three grids: Bottom (1-3 layers), Middle (4-7 layers)

and Top (8-10 layers). Each grid was further divided into five sampling locations (North, East, South, West and Core) Three marked bags were randomly positioned in these locations. For CRS, ARS and CTRL, wherein only 1 pile was built for observation, samples of 1 kg each were drawn from the same marked bags at time 0, 3, 6, and 9 month of storage. For HS, the marked bags in all 3 sealed stacks were sampled at time 0 after which only the assigned Cube or Cocoon for destructive sampling at 3, 6, and 9 months, respectively was opened.

Analyses of samples

Samples gathered were analyzed at the Physical Laboratory of the Food Protection Department, Bureau of Postharvest Research and Extension, Central Luzon State University, Compound, Nueva Ecija. Changes in percentage germination, moisture content, insect density and weight loss were observed. Germination of seeds was established using the rolled paper method described in the International Seed Testing Association (ISTA) Manual (1979). Moisture content of gathered samples was immediately measured with a Dickey-John moisture meter, earlier calibrated through oven drying method. Insect density was determined by sieving the samples and collecting all sifted insects (dead or alive). These were sorted, identified then counted. Weight loss was estimated by weighing all bags of hybrid paddy seeds used in the storage trials at the start and every sampling time. Differences in the recorded total weight of seeds between sampling periods were considered as loss in weight.

Comparative cost analysis

The cost of preserving Mestizo 1 hybrid paddy seeds for 3 and 6 months under Hermetic Storage (HS) using Volcani Cubes or GrainPro Cocoons was estimated. This was compared with the cost of storing seeds for the same periods in the Conventional way (CTRL) inside a warehouse, in Cold Room Storage (CRS), and in Air-

conditioned Room Storage (ACRS).

Results

Technical feasibility of storage technologies

The effects of the various storage technologies on the germination rate of Mestizo 1 hybrid paddy seeds are presented in Table 1. The initial germination rate of seeds stored in all storage technologies tested showed no significant change after 3 months of storage. The 6-month storage trial demonstrated that HS and CRS were comparatively adequate and more effective in preserving the germination rate of seeds than ACRS. The CTRL failed to maintain the

germination rate of seeds at the standard level of 85 % set by the Bureau of Plant Industry. After 9 months, the germination rates of seeds stored in HS, CRS and ACRS declined but the rates still remained above 85 % with seeds in CRS emerging as better preserved than those in HS and ACRS, which exhibited similar effects.

The moisture content of Mestizo 1 hybrid paddy seeds (Table 2) was maintained below 11 % in all technologies during the storage trials. The m.c. of seeds stored in HS remained constant throughout the storage period. However, remarkable decreases in the initial m.c of seeds stored in CRS and ACRS and a significant increase in those kept in CTRL, were noted after 9 months of storage. Insect count (Table 3) revealed that the seeds used in the experiment

Table 1. Mean percent germination rate¹ of Mestizo 1 (PSB Rc72H) hybrid paddy seeds stored under different storage technologies and durations.

ST	Storage duration (month)			
	0	3	6	9
HS	96.16 ab A	96.47 a A	93.30 a A	86.15 b B
CRS	96.80 a A	97.57 a A	92.95 a B	89.60 a C
ACRS	94.30 ab A	94.75 ab A	88.13 b B	85.82 b B
CTRL	92.87 b A	92.92 b A	76.38 c B	74.70 c B

¹ N=15

ST= Storage Techniques, HS= Hermetic storage, CRS= Cold room storage, ACRS= Air-conditioned room storage, CTRL= Conventional room storage.

Means in a column followed by a common small letter are not significantly different at 5 % level of significance.

Means in a row having a common capital letter are not significantly different at 5 % level of significance.

Table 2. Mean percent moisture content¹ of Mestizo 1 (PSB Rc72H) hybrid paddy seeds stored under different storage technologies and durations.

ST	Storage duration (month)			
	0	3	6	9
HS	10.10 a A	10.92 a A	10.66 a AB	10.42 a AB
CRS	10.45 a A	10.86 a A	10.60 a AB	10.39 a B
ACRS	10.18 a A	9.81 b AB	9.91 b AB	9.52 b B
CTRL	9.55 b B	9.83 b AB	10.21 ab A	10.18 a A

¹ N=15

ST= Storage Techniques, HS= Hermetic storage, CRS= Cold room storage, ACRS= Air-conditioned room storage, CTRL= Conventional room storage.

Means in a column followed by a common small letter are not significantly different at 5 % level of significance.

Means in a row having a common capital letter are not significantly different at 5 % level of significance.

were already infested with insects. Predominant insect species found were Lesser Grain Borer (*Rhizopertha dominica* F.), Rice Weevil (*Sitophilus oryzae* L.), Flour Beetle (*Tribolium castaneum* (Herbst)), Red Rust Flour Beetle (*Cryptolestes* sp.), Saw-toothed Grain Beetle (*Oryzaephilus surinamensis* (L)), Flat Grain Beetle (*Lophocateres pussilus* (Klug.)) and Long Headed Flour Beetle (*Latheticus oryzae* Waterhouse). There were no live insects found inside the Cubes and in the samples gathered after 3 and 6 months storage, respectively. A few live insects were recovered after 9 months but the number was much lower compared to CRS and

ACRS.

Insect infestation in the CTRL on the other hand, was consistently highest among the storage technologies all throughout the storage trials. The rank of effectiveness of the storage technologies (from most to least effective) in controlling insect infestation was HS > CRS > ACRS > CTRL. Weight loss in seeds kept in HS was very minimal and consistently the lowest compared with the other technologies throughout the storage trials (Figure 1). The order of effectiveness of the different storage technologies in reducing weight loss, from the most to the least effective was HS > CRS > ACRS > CTRL.

Table 3. Mean percent adult insect density¹ per kg sample of Mestizo 1 hybrid paddy seeds stored under different storage technologies and durations.

ST	Storage duration (month)			
	0	3	6	9
HS	(0.77) 1.13 a C	(0.00) 3.82 b B	(0.00) 3.22 d B	(0.05) 8.42 d A
CRS	(0.40) 0.96 a A	(0.27) 0.38 c A	(0.13) 0.64 c A	(0.15) 0.56 c A
ACRS	(0.13) 0.84 a C	(0.80) 0.76 c C	(21.4) 8.58 b B	(30.20) 38.27 b A
CTRL	(0.20) 0.35 a D	(19.4) 16.95 a C	(60.9) 79.40 a B	(81.0) 147.84 a A

¹ N=15

Data in parenthesis indicates the mean percentage number of alive adult insects per kg seeds

ST= Storage Techniques, HS= Hermetic storage, CRS= Cold room storage, ACRS= Air-conditioned room storage, CTRL= Conventional room storage.

Means in a column followed by a common small letter are not significantly different at 5% level of significance.

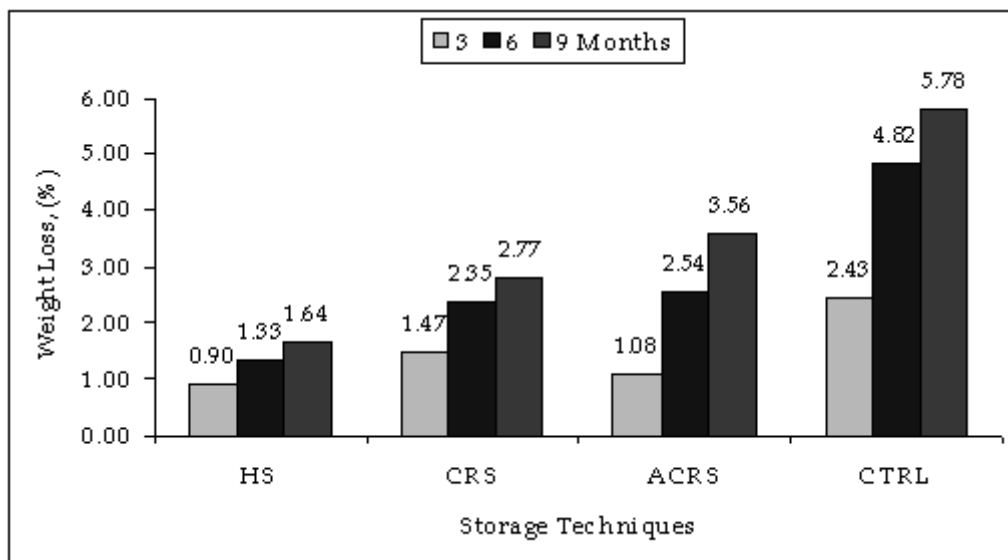


Figure 1. Percent weight loss in Mestizo 1 (PSB Rc72H) hybrid paddy seeds stored at different periods under various storage technologies.

Cost comparison of storage technologies

The estimated cost of storing Mestizo 1 seeds (per bag) using Hermetic, Cold room, Air-conditioned room and Conventional storage technologies for 3, and 6-month period are summarized in Table 4, 5, 6. The sequence of the most to the least cost effective technology after 3 months of storage was: Conventional storage (CTRL) > Hermetic storage (HS) > Air-condition room storage (ACRS) > Cold room storage (CRS). After 6 months of storage the ranking shifted into this order: HS > CTRL > ACRS > CRS.

Discussion

Results showed that Mestizo 1 hybrid paddy seeds can be adequately preserved for 3 months, with the least cost, using the Conventional Storage Technique (CTRL). However, it was no longer effective after 6 months. For this reason, even though it was the second cheapest among the technologies, its usage for storing seeds for 6 months is not sensible. The technologies that preserved the quality of Mestizo 1 hybrid paddy seeds for 6 months and longer were Hermetic Storage (HS) using Volcani Cubes or GrainPro Cocoons; Cold Room Storage (CRS); and Air-conditioned Room Storage (ACRS). Although HS and CRS had similar effects on germination rate of seeds after 6 months, control of insect infestation and weight loss likely associated with water loss was best demonstrated by HS. The quality preservation of Mestizo 1 hybrid paddy seeds inside the Volcani Cubes or GrainPro Cocoons may be ascribed to the effect of low O₂ (3.7-4.4 %) recorded in the naturally modified atmosphere inside the gastight structures. Atmospheres containing low O₂ and/or increased CO₂ could have lethal effects to insect pests (Calderon and Navarro, 1980; Sabio et al., 2004; Tiongson et al., 2003) as well as preserving effects on stored grains (Calderon and Navarro, 1980; Sabio et al., 2004). Moreover, the seeds could have been protected from the possible

effects of water stress ensuing from the constantly oscillating ambient r.h (67-81.81.3 %) and temperature (28.8-32.5 °C) recorded inside the warehouses. The gastight cubes were almost impermeable to water, O₂ and CO₂ gases. Consequently, the moisture content of hermetically sealed seeds remained constant and weight loss was negligible during storage.

At 6 months, HS also emerged the cheapest (PhP126.08 per bag) among the storage technologies tested. The two low temperature storage technologies (i. e. the Cold Room Storage and Air-conditioned Room Storage) although proven efficient in preserving the quality of Mestizo 1 hybrid paddy seeds during extended storage periods, their cost of operation (i.e. PhP131.66 and PhP209.82 per bag for ACRS and CRS, respectively), particularly the Cold Room Storage, could not be justified by the benefits that may be derived from their use. Therefore, for practical and economic considerations, HS seemed to be the best storage option for preserving Mestizo 1 hybrid paddy seeds for 6 months. Additional advantages of this technology were its flexibility, transportability, ease of construction and simplicity of operation and maintenance. However, when adopted, a proper seed distribution system is needed so as not to disrupt the atmosphere in the sealed structure and loss its efficacy in controlling pests and preserving the seeds.

The study demonstrated that Hermetic Storage using Volcani Cubes or GrainPro Cocoons can be a practical and cost effective alternative to low temperature and conventional storage technologies for storing Mestizo 1 hybrid paddy seeds for 6 months or longer. Additional advantages of this technology were its flexibility, transportability, ease of construction and simplicity of operation and maintenance. However, when adopted, a proper seed distribution system is needed so as not to disrupt the atmosphere in the sealed structure and loss its efficacy in controlling pests and preserving the seeds. Cold storage topped the other technologies in preserving the germination rate of Mestizo 1 hybrid seeds but the benefits derived from its usage appeared not

economically justifiable. Conventional storage on the other hand, could be an adequate and cost effective option for storing Mestizo 1 hybrid paddy seeds for 3 months.

Acknowledgement

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Table 4. Cost comparison of using, conventional, hermetic, cold room and air-conditioned room storages for preserving Mestizo 1 (PSB Rc72H) hybrid paddy seeds.

Particular	Storage Period (Months)							
	Three (3)				Six (6)			
	Ctrl	Hs	Crs	Acrs	Ctrl	Hs	Crs	Acrs
Investment Cost, Philippine Peso (Php)	4,112,500.00	87,200.00	641,000.00	811,500.00	4,112,500.00	87,200.00	641,000.00	811,500.00
Operating Expenses, Php Fixed Cost,	904,750.00	24,416.00	141,020.00	178,530.00	904,750.00	24,416.00	141,020.00	178,530.00
Variable Cost	344,800.00	800.00	36,400.00	12,480.00	649,600.00	800.00	68,800.00	18,960.00
Total Operating Expenses, Php	1,249,550.00	25,216.00	177,420.00	191,010.00	1,554,350.00	25,216.00	209,820.00	197,490.00
Capacity, Bag	10,000.00	200.00	1,000.00	1,500.00	10,000.00	200.00	1,000.00	1,500.00
Cost Per Bag, Php	124.96	126.08	177.42	127.34	155.44	126.08	209.82	131.66

Tabela 5. Cost comparison of using conventional, hermetic, cold room and air-conditioned room storages for Mestizo 1 (PSB Rc72H) hybrid paddy seeds for 3 months

Particular	CTRL	HS	CRS	ACRS
Investment Cost, Philippine peso (PhP)	4,112,500.00	87,200.00	641,000.00	811,500.00
<i>Plastic material, Sheeting/Cocoon (5mt)</i>	100,000.00	80,000.00	0.00	0.00
<i>Conventional room storage, 30x30x10m (LWH)</i>	3,600,000.00	0.00	0.00	0.00
<i>Cold room storage with cooling system, 9x6x3m (LWH)</i>	0.00	0.00	600,000.00	0.00
<i>Air-conditioned room storage, 12x6x5m (LWH)</i>	0.00	0.00	0.00	720,000.00
<i>Air-conditioner, 2 units x PhP15,000.00/unit</i>	0.00	0.00	0.00	30,000.00
<i>Multi-layered Kraft bag</i>	360,000.00	7,200.00	36,000.00	54,000.00
<i>Wooden pallets</i>	50,000.00	0.00	5,000.00	7,500.00
<i>Sprayer, 1unit</i>	2,500.00	0.00	0.00	0.00
Operating Expenses				
Fixed Cost, PhP	904,750.00	24,416.00	141,020.00	178,530.00
<i>Depreciation</i>	123,375.00	7,848.00	19,230.00	24,345.00
<i>Repair and maintenance, 1.0%</i>	41,125.00	872.00	6,410.00	8,115.00
<i>Interest on investment, 18.0% p.a.</i>	740,250.00	15,696.00	115,380.00	146,070.00
Variable Cost, PhP	344,800.00	800.00	36,400.00	12,480.00
<i>Labor expenses</i>	42,640.00	800.00	4,000.00	6,000.00
<i>Chemicals and fumigant</i>	300,000.00	0.00	0.00	0.00
<i>Energy consumption</i>	2,160.00	0.00	32,400.00	6,480.00
Total Operating Expenses, PhP	1,249,550.00	25,216.00	177,420.00	191,010.00
Cost Per Bag, PhP	124.96	126.08	177.42	127.34
Basic Information and Assumptions:				
Cost of stock, PhP/kg	120.00	120.00	120.00	120.00
Weight per bag, kg	20.00	20.00	20.00	20.00
Salvage value, %	10.00	10.00	10.00	10.00
Capacity, bag	10,000.00	200.00	1,000.00	1,500.00
Cost of multi-layered Kraft bag, PhP	36.00	36.00	36.00	36.00
Cost of wooden pallet, per piece, PhP	500.00	0.00	500.00	500.00
Number of pallets (1 pallet=100 bags)	100.00	0.00	10.00	15.00
Economic life, year	30.00	10.00	30.00	30.00
Cost of chemicals/fumigant, P10.00/bag/mo x 3mos x capacity, PhP	300,000.00	0.00	0.00	0.00
Labor expenses, PhP	42,640.00	800.00	4,000.00	6,000.00
Handling fee, P2.00/bag/move x 2moves x capacity	40,000.00	800.00	4,000.00	6,000.00
Spraying/fumigation, P220.00/wk x 12wks	2,640.00	0.00	0.00	0.00
Energy consumption, PhP				
Cold room, 2.5kw/hr x 24hr/day x 90days x P7.50/kw x 80%	0.00	0.00	32,400.00	0.00
Air-con, 0.5kw/hr x 24hr/day x 90days x P7.50/kw x 80%	0.00	0.00	0.00	6,480.00
Conventional, 0.5kw/hr x 8hr/day x 90days x P7.50/kw x 80%	2,160.00	0.00	0.00	0.00

Tabela 6. Cost comparison of using conventional, hermetic, cold room and air-conditioned room storages for Mestizo 1 (PSB Rc72H) hybrid paddy seeds for 6 months.

Particular	CTRL	HS	CRS	ACRS
Investment Cost, Philippine peso (PhP)	4,112,500.00	87,200.00	641,000.00	811,500.00
Plastic material, Sheeting/Cocoon (5mt)	100,000.00	80,000.00	0.00	0.00
Conventional room storage, 30x30x10m (LWH)	3,600,000.00	0.00	0.00	0.00
Cold room storage with cooling system, 9x6x3m (LWH)	0.00	0.00	600,000.00	0.00
Air-conditioned room storage, 12x6x5m (LWH)	0.00	0.00	0.00	720,000.00
Air-conditioner, 2 units x PhP15,000.00/unit	0.00	0.00	0.00	30,000.00
Multi-layered Kraft bag	360,000.00	7,200.00	36,000.00	54,000.00
Wooden pallets	50,000.00	0.00	5,000.00	7,500.00
Sprayer, 1unit	2,500.00	0.00	0.00	0.00
Operating Expenses				
Fixed Cost, PhP	904,750.00	24,416.00	141,020.00	178,530.00
Depreciation	123,375.00	7,848.00	19,230.00	24,345.00
Repair and maintenance, 1.0%	41,125.00	872.00	6,410.00	8,115.00
Interest on investment, 18.0% p.a.	740,250.00	15,696.00	115,380.00	146,070.00
Variable Cost, PhP	649,600.00	800.00	68,800.00	18,960.00
Labor expenses	45,280.00	800.00	4,000.00	6,000.00
Chemicals and fumigant	600,000.00	0.00	0.00	0.00
Energy consumption	4,320.00	0.00	64,800.00	12,960.00
Total Operating Expenses, PhP	1,554,350.00	25,216.00	209,820.00	197,490.00
Cost Per Bag, PhP	155.44	126.08	209.82	131.66
Basic Information And Assumptions:				
Cost of stock, PhP/kg	10.00	120.00	120.00	120.00
Weight per bag, kg	20.00	20.00	20.00	20.00
Salvage value, %	10.00	10.00	10.00	10.00
Capacity, bag	10,000.00	200.00	1,000.00	1,500.00
Cost of multi-layered Kraft bag, PhP	36.00	36.00	36.00	36.00
Cost of wooden pallet, per piece, PhP	500.00	0.00	500.00	500.00
Number of pallets (1 pallet=100 bags)	100.00	0.00	10.00	15.00
Economic life, year	30.00	10.00	30.00	30.00
Cost of chemicals/fumigant, P10.00/bag/mo x 6mos x capacity, PhP	600,000.00	0.00	0.00	0.00
Labor expenses, PhP	45,280.00	800.00	4,000.00	6,000.00
Handling fee, P2.00/bag/move x 2moves x capacity	40,000.00	800.00	4,000.00	6,000.00
Spraying/fumigation, PhP220.00/wk x 24wks	5,280.00	0.00	0.00	0.00
Energy consumption, PhP				
Cold room, 2.5kw/hr x 24hr/day x 180days x PhP7.50/kw x 80%	0.00	0.00	64,800.00	0.00
Air-con, 0.5kw/hr x 24hr/day x 180days x PhP7.50/kw x 80%	0.00	0.00	0.00	12,960.00
Conventional, 0.5kw/hr x 8hr/day x 180days x PhP7.50/kw x 80%	4,320.00	0.00	0.00	0.00