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STATUS AND PROSPECTS OF HERMETIC STORAGE OF RICE SEEDS IN THE PHILIPPINES

Caesar Joventino M. Tado[1]* and Martin Gummert[2]

[1]Philippine Rice Research Institute, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines,
[2]International Rice Research Institute, DAPO Box 7777, Metro Manila, Philippines
*Corresponding author's e-mail: *cjmtado@yahoo.com*

ABSTRACT

Hermetic storage is a type of modified atmosphere storage that uses air-tight storage containers or structures that reduces oxygen (O_2) and increases carbon dioxide (CO_2) concentration through respiration of the rice seeds, insects and other aerobic organisms inside the sealed container. It provides for a sustainable, pesticide-free safe storage of seeds that prevents insect pest infestation particularly in hot, humid climates. In the past, the application of hermetic storage in the Philippines consisted of household storage of seeds of cereal grains and vegetables by individual farmers using "air-tight" containers. In the 1990s, the National Food Authority employed hermetic storage of milled rice using the Volcani Cube. In 2002, the Philippine government launched the Hybrid Rice Commercialization Program (HRCP) which promotes the utilization of hybrid rice seeds to boost rice production in the country. Since the recommended locally-developed variety, the PSB Rc72H, also popularly known as "Mestizo 1" is more vulnerable to insect pest infestation and fungi than inbreds, the seed producers resorted to use hermetic storage to preserve their costly seeds. By the time the HRCP program ended in 2005, several types of hermetic storage containers such as Volcani Cubes, GrainPro Cocoons™, Super Grain Bags, IRRI Superbags, and PhilRice-developed SACLOB have already been introduced to the market. Interest on hermetic storage of rice seeds waned during the post-HRCP years. Cognizant of its potential in the local rice seed industry, IRRI and PhilRice, with funding support from the Asian Development Bank, started advocating the hermetic storage technology to the seed growers and other stakeholders in the country. This paper presents the status of hermetic storage of rice seeds in the Philippines, constraints in its adoption, as well as future prospects of the technology.

Key words: rice seed, grain storage, modified atmospheres, pesticide-free alternatives, hermetic storage, quality preservation.

INTRODUCTION

The very high relative humidity and temperature in many tropical countries results in a faster respiration rate of stored paddy, increased insect activity and hastens the development of moulds. These factors, coupled with poor drying techniques, contribute to the deterioration of quality of the grains, which ultimately affects its germination and seedling vigor. In the Philippines, the minimum standard for germination of high quality seeds is 85% (Orge and

Abon, 2007). A drop in germination of the rice seeds below the standard would have a significant effect on the income of the seed producers, as this would mean around 50% reduction in the price of seeds.

Fumigants are still widely used to control storage pests due to their relative ease of application. Methyl bromide is a broad spectrum pesticide that has been used to control storage insect pests, pathogens and rodents. However, its use is being phased out in accordance with the Montreal protocol due to its effect on the earth's stratospheric ozone layer (EPA, 2008). In contrast, phosphine has continued to be the most widely-used fumigant for the control of stored-product insects, particularly in developing countries because of its low cost, ease of use, and absence of residues (Zeng et al., 2007; Abdullahi, 2010). However, the sustained viability of this fumigant has been challenged by the observed development of resistance of some insects toward phosphine in Asia, Australia, and Brazil (Nayak et al., 2003; Athie and Mills, 2005; Pimentel et al., 2006; Ahmedani et al., 2007; Pimentel et al., 2008).

Due to the problems associated with the use of pesticide-based pest control in storage products, non- chemical and environment-friendly methods of pest control in the postharvest sector are becoming increasingly important (Villers et al., 2007a; Silva et al., 2012). Storage problems often occur in high relative humidity and temperature, and in the presence of adequate oxygen. These problems are eliminated through a low O_2 and high CO_2 atmosphere produced through respiration processes of biological agents (Villers et al., 2010).

Hermetic storage is a type of modified atmosphere storage that uses air-tight storage containers or structures that reduces the O_2 and increases the CO_2 concentration through respiration of the rice seeds, insects and other aerobic organisms inside the sealed container. It provides for a sustainable, pesticide-free safe storage of seeds that prevents insect pest infestation particularly in hot, humid climates. It also prevents the development of cancer causing mycotoxins such as aflatoxins and ochratoxin A (OTA). The low permeability of the hermetic structure also maintains safe constant moisture levels in the stored product regardless of ambient exterior humidity (Villers et al., 2007b).

APPLICATION OF HERMETIC STORAGE IN THE PHILIPPINES

In the Philippines, paddy rice are commonly bagged and stored in warehouses at ambient conditions, which range from 29-33^{o}C and 65-75% r.h. The seeds are exposed to ambient air, insects, rodents and birds. Losses in both quantity and quality are often experienced due to the consumption by insects, rodents and birds.

Moisture migration is the phenomenon that discourages the use of airtight storage in the tropics. With the advances in the development of sealed flexible plastic containers that reduce the intensity of moisture migration, the use of hermetic storage for outdoor, alternative or temporary storage facilities for use by farmers' organizations, cooperatives and seed growers became feasible in the Philippines and other tropical countries (Navarro et al., 1999).

In the past, the application of hermetic storage in the Philippines consisted of household storage of seeds of cereal grains and vegetables by individual farmers using "air-tight" containers. The attempts by the government to adopt this technology for storing grains started in the 1990's through joint research and development programs that were carried out by the Agricultural Research Organization (ARO) of Israel and the Philippine Center for Postharvest Development and Mechanization (PhilMech - formerly NAPHIRE and BPRE) of the Philippines to study outdoor storage of paddy and maize using hermetically sealed plastic liners called Volcani Cubes. Results of the experiments showed that under Philippine climatic

conditions, the gastight storage prevented moisture migration during 4 months of storage and provided acceptable protection by maintaining the number of live insects below the threshold of economic damage without the need for pesticides (Alvindia et al., 1994; Navarro et al., 1997).

Laboratory and field trials using sealed flexible structures of 10 tonne capacity also showed that paddy can be stored hermetically at 18% moisture content (w.b.) for up to 1 month, without any perceptible deterioration (Donahaye et al., 2001).

The investigation on the suitability of hermetic storage to store milled rice and its by-products was conducted by the National Food Authority. Laboratory experiments indicated that the quality of rice bran was preserved during 6 months storage (De Dios et al., 2007). Field results showed that after 3, 6 and 11 months of continuous storage, the oxygen concentrations in the Volcani Cubes dropped to 11.4%, 5.4% and 2.7%, respectively. The modified atmosphere also suppressed insect development, and the quality of milled rice remained high throughout the storage period. In contrast, the untreated control stacks stored under ambient conditions were heavily infested by insects after 3 months of storage (De Dios et al., 2001).

Promotion of the hermetic storage technology for paddy and maize to the Philippine countryside was conducted by PhilMech in the late 1990s (Estigoy, 2001), although the focus was for food and feed, respectively. The use of this technology for storage of rice seeds took a big leap during the implementation of the Hybrid Rice Commercialization Program (HRCP) from 2002 to 2005. With the launching of HRCP in 2002, commercialization of the hybrid rice technology became the Philippine agriculture's banner program in attaining self-sufficiency and increasing productivity and profitability in rice, and generating rural employment (Redoña et al., 2005). Hybrid rice is known to have a yield advantage of 15% over inbred varieties under the same input levels (Tu et al., 2000).

Since the recommended locally-developed variety, the PSB Rc72H, also popularly known as "Mestizo 1" was more vulnerable to insect pest infestation and fungi than inbreds, storing these seeds for up to 6 months, in time for the next cropping season became a big problem for HRCP implementers. Consequently, researchers investigated the technical feasibility and cost effectiveness of hermetic storage using Volcani Cubes or GrainPro Cocoons™ to store Mestizo 1 seeds, in comparison with low temperature storage technologies (Sabio et al., 2006). With its technical and economic feasibility ascertained, hybrid rice seed producers resorted to use hermetic storage to preserve their costly seeds.

The Philippine Rice Research Institute (PhilRice), being the procurer and distributor of hybrid rice seeds during the initial years of HRCP implementation adopted hermetic storage technology to store the large quantities of seeds that could no longer be accommodated in its cold storage facilities. During this period, PhilRice was able to develop its own hermetic container called "SACLOB", using locally-available and inexpensive material, with a simple but durable zipping mechanism (Orge et al., 2008). The material used was 0.8mm thick PVC tarpaulin sheet, with Velcro strip as zipping mechanism (Fig. 1).

Its performance (Fig. 2) was found to be comparable to the imported ones (Estoy et al., 2008; Gergon et al., 2011). Collaborative work of IRRI with GrainPro, Inc. on hermetic storage systems also led to the development of a 50 kg Superbag that fits inside the traditional storage bags that farmers can easily use to hermetically store small amounts of seeds (Rickman and Aquino, 2007; Villers and Gummert, 2009). By the time the HRCP program ended in 2005, several types of hermetic storage containers such as Volcani Cubes, GrainPro Cocoons™, Grainsafe™, IRRI Superbags, and PhilRice-developed SACLOB have already

been introduced to the market. However, interest on hermetic storage of rice seeds waned during the post-HRCP years.

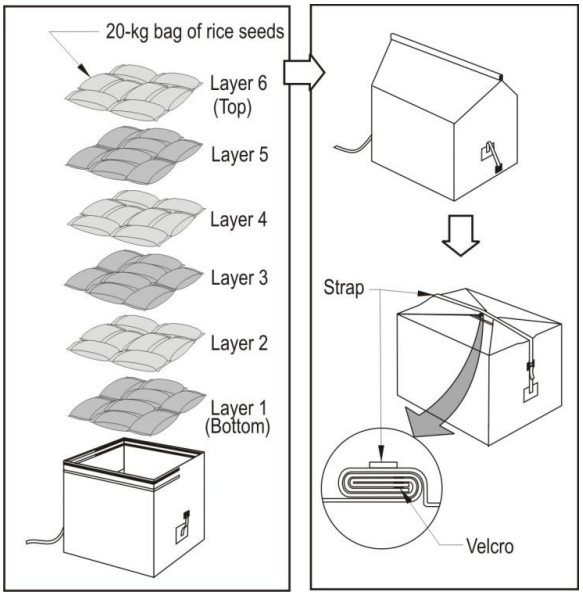

Fig. 1- The SACLOB hermetic storage container developed by PhilRice

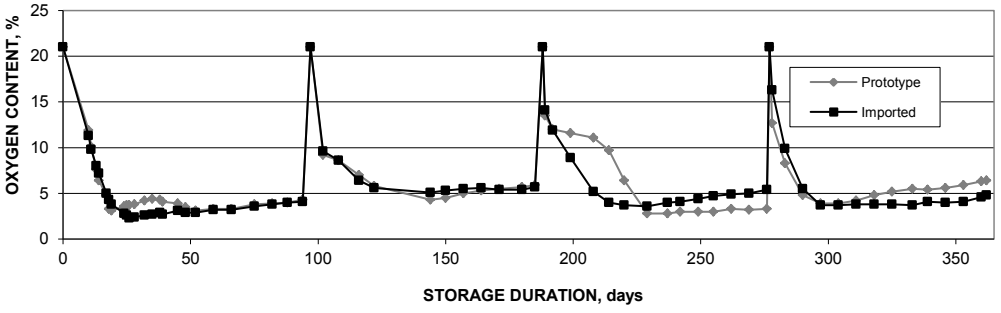

Fig. 2- Comparison between the oxygen level inside the SACLOB and its imported counterpart.

CURRENT EFFORTS TO PROMOTE HERMETIC STORAGE IN THE PHILIPPINES

Cognizant of its potential in the local rice seed industry, IRRI and PhilRice, with funding support from the Asian Development Bank, are currently advocating the hermetic storage technology to the seed growers and other stakeholders in the country. Information dissemination to seed growers and intermediaries are being done through the postharvest learning alliance, a multi-stakeholder platform where members freely share their experiences

and technologies to others. Adaptive research on the technology are also being conducted by farmers' groups in three pilot provinces in the country with the support from the private sector in terms of technology (GrainPro, Inc.) and funding (Catholic Relief Services). Constraints on the availability of Superbags and Cocoons™ are now being sorted out through partnership between the supplier and a large distributor of agricultural and veterinary products and supplies in the country. The project has also come up with information materials such as posters and video clips in the major local dialects. Finally, training on the technology has been integrated in the capacity enhancement programs of the government for its agricultural extension workers throughout the country under the Philippine Food Staples Sufficiency Program of the country's Department of Agriculture.

FUTURE PROSPECTS

With the increasing emphasis on chemical-free and environment-friendly methods of controlling pests in the postharvest sector, hermetic storage technology is seen to play a vital role in the Philippine rice seed industry in the near future. With the government's adoption of hybrid rice technology as one of the main interventions to attain its goal of self-sufficiency in food staples, many seed growers and other stakeholders will be using hermetic technology to store their precious seeds. The success of Bayer CropScience, one of the world's largest seed companies, in shifting from traditional warehouse storage to hermetic storage of its hybrid rice seeds (Villers and Gummert, 2009), points to the commercial viability of the technology on the large scale. On the other hand, the Superbag will also allow small farmers to use relatively cheap hermetic storage containers for their seeds. Finally, experience gained by farmers on the suitability of using this technology to store other products such as mungbean and cacao will further boost its application in the country.

REFERENCES

Abdullahi N (2010) The effect of insecticides and airtight storage on the storability of cowpea in Maiduguri, Nigeria. Afr J Gen Agric 6(1): 31-37

Ahmedani MS, Shaheen N, Ahmedani MY, Aslam M (2007) Status of phosphine resistance in khapra beetle, *Trogoderma granarium* (Everts) strains collected from remote villages of Rawalpindi District. Pak Entomol 29(2): 95-102

Alvindia DG, Caliboso FM, Sabio GC, Regpala AR (1994) Modified atmosphere storage of bagged maize outdoors using flexible liners: a preliminary report. In: Highley E, Wright EJ, Banks HJ, Champ BR (eds) Proceedings of the 6th International Working Conference on Stored-product Protection, CAB International, University Press, Cambridge, Vol. 1: 22-26

Athie I, Mills KA (2005) Resistance to phosphine in stored-grain insect pests in Brazil. Braz J Food Technol 8(2): 143-147

De Dios CV, Cosico MFA, Julian DD, Dator JV, Martinez EM, Tiongson RL (2001) Adoption of hermetic storage on milled rice using the Volcani Cube® in the Philippines. In: Donahaye JE, Navarro S, Leesch JG (eds) Proceedings of the International Conference on Controlled Atmosphere and Fumigation in Stored Products, Fresno, CA. 29 Oct. - 3 Nov. 2000. Executive Printing Services, Clovis, CA, USA. pp 251-260

De Dios CV, Natividad DG, Tampoc EA, Javier LG (2007) Storage behaviour of rice and rice bran in hermetically sealed container. In: Donahaye EJ, Navarro S., Bell C, Jayas D, Noyes R, Phillips TW (eds) Proceedings of the International Conference on Controlled

Atmosphere and Fumigation in Stored products, Gold-Coast Australia 8-13 August 2004. FTIC Ltd. Publishing, Israel, pp 405-425

Donahaye JE, Navarro S, Andales S, Del Mundo AM, Caliboso F, Sabio G, Felix A, Rindner M, Azrieli A, Dias R (2001) Quality preservation of moist paddy under hermetic conditions. In: Donahaye JE, Navarro S, Leesch JG (eds) Proceedings of the International Conference on Controlled Atmosphere and Fumigation in Stored Products, Fresno, CA. 29 Oct. - 3 Nov. 2000. Executive Printing Services, Clovis, CA, USA. pp 209-225

EPA (2008) Revised guidance note for ozone depleting substances: Methyl bromide. Environmental Protection Agency, pp 3-4

Estigoy R (2001) Experiences in the transfer of outdoor storage technology among extension workers and users in the Philippine grains industry. In: Donahaye JE, Navarro S, Leesch JG (eds) Proceedings of the International Conference on Controlled Atmosphere and Fumigation in Stored Products, Fresno, CA. 29 Oct. - 3 Nov. 2000. Executive Printing Services, Clovis, CA, USA. pp 355-363

Estoy GF, Estoy AB, Rendon GA, Tado CJM, Orge RF (2008) Performance verification of a semi-airtight canvas-lined seed storage box. In: PhilRice R&D Highlights 2007. Philippine Rice Research Institute, p 225

Gergon EB, Abon JEO, Gagelonia EC (2011) Pilot testing of SACLOB and super bag hermetic storage systems in the Philippines. In: PhilRice R&D Highlights 2010. Philippine Rice Research Institute, pp 173-175

Navarro S, Donahaye JE, Caliboso FM, Sabio G (1997) Outdoor storage of corn and paddy using sealed-stacks in the Philippines. In: Villapando I, Ramos CL, Salcedo BGA (eds) Postharvest Technology Towards Attaining Food Security. Proceedings of the 18th ASEAN Seminar on Grains Postharvest Technology, Manila, Philippines, 11-13 March 1997, pp 225-236

Navarro S, Donahaye E, Rindner M, Azrieli A, Dias R (1999) Protecting grain without pesticides at the farm level in the Tropics. In: Johnson GI, To Le V, Duc ND, Webb MC (eds) Proceedings of the 19th ASEAN Seminar on Postharvest Technology, Ho Chi Minh City, Vietnam, 9-11 November 1999, ACIAR Proceedings No. 100, pp 353-363

Nayak MK, Collins PJ, Pavic H, Cao Y (2003) Developments in phosphine resistance in China and possible implications for Australia. In: Wright EJ, Webb MC, Highley E (eds) Stored Grain in Australia 2003. Proceedings of the Australian Postharvest Technical Conference, Canberra., 25-27 June 2003. CSIRO Stored Grain Research Laboratory, Canberra, pp 156-159

Orge RF, Abon JEO (2007) Experiences, lessons learned in seed storage. In: Gaspar MG, Roque AS, Gonzales DB (eds) The pains of success in hybrid rice commercialization in the Philippines. Philippine Rice Research Institute, pp 185-191

Orge RF, Abon JEO, Parpados NG, Gergon EB (2008) Development of a fumigant-free seed storage system. In: PhilRice R&D Highlights 2007. Philippine Rice Research Institute, pp 223-224

Pimentel MAG, Faroni LRDA, Neto AP, Garcia FM (2006) Phosphine resistance, respiration rate and fitness consequences in *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). In: Lorini B, et al. (eds) Proceedings of the 9th International Working Conference on Stored Product Protection, 15 to 18 October 2006, Campinas, São Paulo, Brazil. Brazilian Post-harvest Association - ABRAPOS, Passo Fundo, Brazil, pp 344-351

Pimentel MAG, Faroni LRA, Batista MD, da Silva FH (2008) Resistance of stored-product insects to phosphine. Pesq Agropec Bras, Brasilia 43(12): 1671-1676

Redoña ED, Perez LM, Hipolito LR, Elec VE, Pacada IA, Borines LM, Solis RO, Ordoñez SA, Agarcio J (2005) Harnessing molecular markers in hybrid rice commercialization in the Philippines. In: Toriyama K, Heong KL, Hardy B (eds) Rice is life: Scientific perspectives for the 21st century. Proceedings of the world rice research conference. International Rice Research Institute, Los Baños (Philippines) and Japan International Research Center for Agricultural Sciences, Tsukuba (Japan), pp 166-169

Rickman JF, Aquino E (2007) Appropriate technology for maintaining grain quality in small-scale storage. In: Donahaye EJ, Navarro S., Bell C, Jayas D, Noyes R, Phillips TW (eds) Proceedings of the International Conference on Controlled Atmosphere and Fumigation in Stored products, Gold-Coast Australia 8-13 August 2004. FTIC Ltd. Publishing, Israel, pp 149-157

Sabio GS, Dator JV, Orge RF, Julian DDT, Alvindia DG, Miranda GC, Austria MC (2006) Preservation of Mestizo 1 (PSB Rc72H) seeds using hermetic and low temperature storage technologies. In: Lorini B, et al. (eds) Proceedings of the 9th International Working Conference on Stored Product Protection, 15 to 18 October 2006, Campinas, São Paulo, Brazil. Brazilian Post-harvest Association - ABRAPOS, Passo Fundo, Brazil, pp 946-955

Silva GN, Faroni LRA, Sousa AH, Freitas RS (2012) Bioactivity of *Jatropha curcas* L. to insect pests of stored products. J Stored Prod Res 48(1): 111-113

Tu J, Zhang G, Datta K, Xu C, He Y, Zhang Q, Khush GS, Datta SK (2000) Field performance of transgenic elite commercial hybrid rice expressing *Bacillus thuringiensis* δ-endotoxin. Nature Biotechnol 18(10): 1101-1104

Villers P, De Bruin T, Navarro S (2007a) Advances in hermetic storage as a methyl bromide. In: Donahaye EJ, Navarro S., Bell C, Jayas D, Noyes R, Phillips TW (eds) Proceedings of the International Conference on Controlled Atmosphere and Fumigation in Stored products, Gold-Coast Australia 8-13 August 2004. FTIC Ltd. Publishing, Israel, pp 207-223

Villers P, De Bruin T, Navarro S (2007b) Development and applications of the hermetic storage technology. In: Lorini B, et al. (eds) Proceedings of the 9th International Working Conference on Stored Product Protection, 15 to 18 October 2006, Campinas, São Paulo, Brazil. Brazilian Post-harvest Association - ABRAPOS, Passo Fundo, Brazil, pp 719-729

Villers P, Gummert M (2009) Seal of Approval. Rice Today 8(1): 36-37

Villers P, Navarro S., De Bruin T (2010) New applications of hermetic storage for grain storage and transport. In: Carvalho MO, et al. (eds) Proceedings of the 10th International Working Conference on Stored Product Protection, 27 June to 2 July 2010, Estoril, Portugal. Julius Kühn-Institut, Berlin, Germany, pp 446-451

Zeng L, Zhang X., Shang Z, Luo Z., Tian Y, Huang Z., Wang X, He D, Leng Y (2007) Phosphine fumigation of bagged and bulk paddy in Southern China using conventional and slow release application. In: Donahaye EJ, Navarro S., Bell C, Jayas D, Noyes R, Phillips TW (eds) Proceedings of the International Conference on Controlled Atmosphere and Fumigation in Stored products, Gold-Coast Australia 8-13 August 2004. FTIC Ltd. Publishing, Israel, pp 547-556