ijPPHT
e ISSN-2231-6426
Volume 6 | Issue 1 | June, 2015 | 48-53
Visit us: *www.researchjournal.co.in*
International Journal of Processing and Post Harvest Technology

RESEARCH PAPER

DOI: 10.15740/HAS/IJPPHT/6.1/48-53

Management of post harvest pests of maize in India through enhanced hermetic storage

P. LAKSHMI SOUJANYA*, J.C. SEKHAR, G.K. CHIKKAPPA[1] AND P. KUMAR[1]
Winter Nursery Centre, ICAR-Indian Institute of Maize Research, Rajendranagar, HYDERABAD (A.P.) INDIA
Email : soujanyak.scientist@gmail.com
[1]Directorate of Maize Research, Pusa Campus, NEW DELHI, INDIA

*Author for Correspondence

Research chronicle : Received : 04.12.2014; **Revised :** 20.04.2015; **Accepted :** 01.05.2015

SUMMARY :

Effectiveness of hermetic storage in combination with botanical *Ageratum conyzoides* for the control of post harvest pests of maize *Sitophilus oryzae* (L.) and *Sitotroga cerealella* (Oliv.) was evaluated under artificial infestation by different packing materials. It was observed that High density polythene (HDPE) bag and Double Layered Polythene (DLP) bag with *A. conyzoides* are most effective in controlling *S. oryzae* and *S. cerealella*. The number of F_1 progeny of *S. oryzae* and *S. cerealella* emerged in treatments ranged from 7.75 to 21.70 and 8.70 to 25.50, respectively with each mean being significantly different from each other. Both HDPE and DLP bag in combination with *A. conyzoides* recorded lowest adult emergence, minimum grain damage and weight loss when infested by *S. oryzae* and *S. cerealella*. HDPE bag and double layered polythene bag with *A. conyzoides* recorded per cent damage of 4, 5.70 and 5.0, 7.0 and minimum losses of 0.61, 0.94 and 0.37, 0.52 by *S. oryzae* and *S. cerealella*, respectively. The results demonstrated that it is technically feasible to control post harvest pests of maize in India through enhanced hermetic storage by utilizing locally available botanicals.

KEY WORDS : Botanicals, Hermetic storage, Maize, Post harvest loss, *Sitophilus oryzae*, *Sitotroga cerealella*

How to cite this paper : Soujanya, P. Lakshmi, Sekhar, J.C., Chikkappa, G.K. and Kumar, P. (2015). Management of post harvest pests of maize in India through enhanced hermetic storage. *Internat. J. Proc. & Post Harvest Technol.,* **6** (1) : 48-53.

In India the pests that attack maize in storage are rice weevil, *Sitophilus oryzae* L. (Coleoptera: Curculionidae); Angoumois grain moth, *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechidae); rice moth, *Corcyra cephalonica* (St.); lesser grain borer *Rhizopertha dominica* (F.) (Bostrichidae: Coleoptera) and red flour beetle *Tribolium castaneum* (Herbst) (Tenebrionidae: Coleoptera) (Sinha, 1994). Among them *S. oryzae* and *S. cerealella* are most dominant particularly in small scale and on farm maize storage. In

India it is estimated that about 2.45 per cent of maize is lost at farmers' level during harvesting, threshing, winnowing, transportation and storage. Management of agricultural pests over the past half century has been largely depending on the use of synthetic chemical pesticides and fumigants for post-harvest protection of crops (Isman, 2006). Misuse or overuse of chemicals have serious repercussions, such as the development of resistance, pollution of the environment, effect on non-target organisms and food poisoning (Musa *et al.*, 2009).

In India, maize is stored in traditional storage structures includes mud bin, bamboo reed bin, Thekka, metal drums, gunny bags made of jute; improved storage structures like Pusa bin, coal tar drum bin, Domestic Hapur Bin, Chittore Stone Bin, double walled polyethylene lined bamboo bin fitted with a lid and with a plastering of mud inside and outside (Chouksey, 1985); community storage structures (Birewar, 1985), Silos, brick built godowns, Cover and Plinth storage are the most popular storage systems. In western Australia, sealed metal silos in combination with carbon dioxide treatment are popular for storing wheat and grain legumes (Andrews *et al*., 1994). Low oxygen concentration causes insect mortality, so hermetic storage such as Purdue Improved Cowpea Storage (PICS), super grain bags, cocoons and others, are being promoted as cheap and effective ways to control storage insect pests in Asia (Quezada *et al.*, 2006). In central America, grain in the metal silos is treated with Phostoxin, a highly poisonous fumigant (Yusuf and He, 2011). Phasing out of Methyl bromide, an effective fumigant in developed countries, (TEAP, 2000; Fields and White, 2002) inspired the search for alternative storage methods including inert dusts, wood ash, biological control and others, but none were particular efficient and cost-effective (Golob and Hanks, 1990; Golob, 2002; Smith *et al.*, 2006). The use of hermetic storage is recently becoming popular for control of storage pests as it offers residue free storage system for beans, coffee, rice, maize, pulses and seeds (Navarro, 2006 and Sabio *et al.*, 2006). Maize stored in these bags will develop a modified atmosphere of low oxygen and high carbon dioxide content, created by respiration of living organisms such as insects and fungi. As plant based products are effective and benign tools in curtailing the menace caused by insect pests particularly during storage present trials were conducted with different types of packing material and in combination with botanical *Ageratum conyzoides* leaf powder in controlling the major storage pests namely rice weevil and anguomois grain moth.

EXPERIMENTAL METHODS

The experiment consists of five treatments using two types of packing material with one botanical. The treatments were T_1: Double layered polythene (DLP) bag T_2: High density polythene (HDPE) bag T_3 : Double layered polythene bag with *A. conyzoides* T_4: HDPE bag with *A. conyzoides*. T_5: Cloth bag with out botanical (control). The botanical was applied only once at the beginning of the experiment. The treatments were arranged in a Completely Randomized Design with four replications resulting in a total of 20 storage containers.

Collection of plant material :

The plant material of *Ageratum conyzoides* was collected from maize and rice fields, washed thrice with distilled water, shade dried for one week, grinded to a fine powder using blender and sieved through standard U.S. Sieve number 25.

Description of storage containers, grains and infestation with insects :

Polythene bags (400 guaze) and HDPE bags were purchased from local market. Their dimensions were 30 cms (height) by 26.5 cms (width) and they hold 2 kg grains. After filling the HDPE bag with grain, the free plastic portion (above the grain) was squeezed in order to remove excess air. The opening was then closed by tightly twisting the free portion and tied with thin plastic rope. In case of double layered polythene bag the top end of the bag was again twisted, folded back and tied with thin plastic rope. Before starting the experiment maize grain was cleaned, by removing broken and discoloured seeds and the moisture content was analyzed. Each packing material was filled with 2 kg of maize grain and 40 adult weevils, 350 eggs of *S. cerealella* were released separately into each packing material.

Rearing of test insects :

The rice weevil, *S. oryzae* were obtained from laboratory cultures maintained for the last 3 years in the dark at 28-30°C and 55-65 per cent relative humidity reared on whole maize at 12-13 per cent moisture content. The culture of *S. cerealella* was carried out by confining

10-20 freshly emerged moths of both sexes in 1l plastic jars with 500 g of maize grains maintained at 28 ± 2° C (Heinrichs *et al.*, 1985). The jars were covered with muslin cloth and tied with rubber band. Eggs of *S. cerealella* were obtained according to the technique of Stockel and Turtaut (1970).

Measuring grain damage and weight loss :

Grain damage is of a qualitative nature and is usually reported as a percentage of grains damaged in a sample (Boxall, 2002). Grain weight loss was determined using the count and weight method of Gwinner *et al.* (1996).

$$\text{Weight loss (\%)} = \frac{(Wu \times Nd) - (Wd \times Nu) \times 100}{Wu \times (Nd + Nu)}$$

where as,

Wu= Weight of undamaged grain.

Wd= Weight of damaged grain.

Nd= Number of damaged grain.

Nu= Number of undamaged grain.

Data collected :

The moisture content of the maize was measured using U.S. Farmex moisture meter. After 3 weeks of exposure period adults of *S. oryzae* were removed and data on per cent survival was taken. Data on grain damage, grain weight loss and number of adults emerged were also taken at 5 months after storage.

Statistical analysis :

Data were transformed to homogenize the variance (Gomez and Gomez, 1984) before analysis and were analyzed using one-way analysis of variance (ANOVA) using SAS version 9.2 software packages.

EXPERIMENTAL FINDINGS AND ANALYSIS

The ANOVA for survival of *S. oryzae* on treated maize showed significant differences for treatments (Fig. 1). The per cent survival of *S. oryzae* after 3 weeks of exposure ranged from 2 to 36 per cent. Survival in the four treatments ranged from 2 to 8.70 per cent, lowest in high density polythene bag with *A. conyzoides* while it was greatest in control (untreated maize stored in cloth bag). The number of emerged F_1 progeny of *S. oryzae* and *S. cerealella* showed high significant difference ($P < 0.001$) between treatments and control (Fig. 2). The number of F_1 adult *S. oryzae* and *S. cerealella* emerged

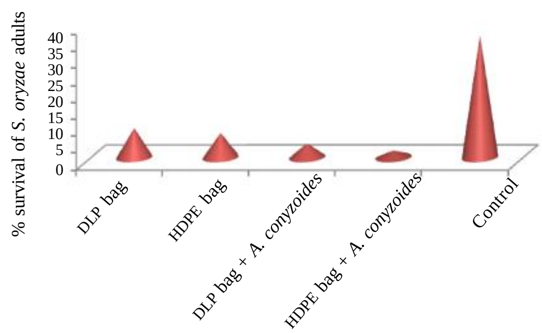

Fig. 1 : Survival (%) of parent *Sitophilus oryzae* adults exposed for 3 weeks on treated maize stored in different packing materials

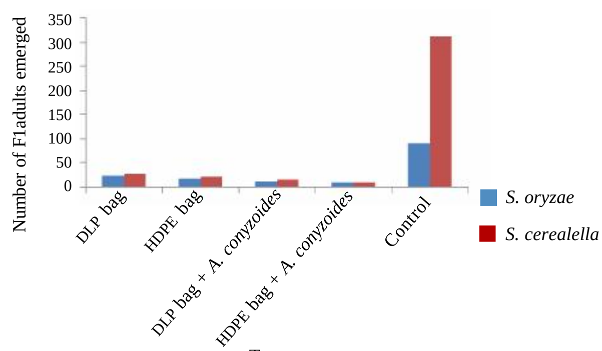

Fig. 2 : Number of F_1 adults of *S. oryzae* and *S. cerealella* emerged when exposed for 3 weeks on treated maize stored in different packing materials

Table 1 : Effect of different packing materials on grain damage (%) and grain weight loss (%) of maize by *S. oryzae* and *S. cerealella* stored for a period of 5 months

Treatments	Grain damage (%)		Grain weight loss (%)	
	S. oryzae	*S. cerealella*	*S. oryzae*	*S. cerealella*
Double layered polythene bag	$9.50^{b} \pm 0.28$	$13.75^{b} \pm 0.51$	$2.18^{b} \pm 0.40$	$1.95^{b} \pm 0.25$
High density polythene bag	$6.75^{c} \pm 0.29$	$8.25^{c} \pm 0.26$	$1.87^{b} \pm 0.35$	$1.34^{c} \pm 0.15$
Double layered polythene bag with *A. conyzoides*	$5.70^{c} \pm 0.31$	$7.0^{c} \pm 0.46$	$0.94^{c} \pm 0.25$	$0.52^{d} \pm 0.08$
High density polythene bag with *A. conyzoides*	$4.0^{d} \pm 1.13$	$5.0^{d} \pm 0.99$	$0.61^{d} \pm 0.21$	$0.37^{d} \pm 0.06$
Control	$22.75^{a} \pm 1.09$	$23.25^{a} \pm 1.03$	$5.10^{a} \pm 0.26$	$4.36^{a} \pm 0.31$

Means for treatment followed by the same upper-case letter are not significantly different ($P \geq 0.05$). Each value is mean of four replications in control were 89.50 ± 0.17, 312.25 ± 0.31, respectively. The number of F_1 adults of *S. oryzae* and *S. cerealella* emerged in treatments ranged from 7.75 ± 1.13 to 21.70 ± 0.28 and 8.70 ± 0.99 to 25.50 ± 0.51, respectively with each mean being significantly different from each other. The per cent grain damage showed high significant difference ($P < 0.001$) between treatments and control (Table 1). Grain in control was heavily damaged reaching 22.75 and 23.25 per cent grain damage for *S. oryzae* and *S. cerealella,* respectively. All pest control treatments provided good control of insect damage ranging from 4 to 13.75 per cent. HDPE bag with *A. conyzoides*, double layered polythene bag with *A. conyzoides* recorded per cent damage of 4, 5.70 and 5.0, 7.0 for *S. oryzae* and *S. cerealella,* respectively. Although damage in HDPE bag and double layered polythene bag with out botanical was low it was 6.75, 9.50 in HDPE bag, 8.25, 13.75 in double layered polythene bag for *S. oryzae* and *S. cerealella,* respectively.

The per cent weight loss followed the same pattern of per cent grain damage and showed high significant difference ($P < 0.001$) between treatments and control (Table 1). Grain stored as control suffered substantial weight losses although they varied from 4.36 to 5.10 for *S. cerealella* and *S. oryzae,* respectively. All pest control treatments kept the losses at low levels. However, for HDPE bag and double layered polythene bag the losses only amounted to 1.87, 2.18 and 1.34, 1.95 by *S. oryzae* and *S. cerealella,* respectively. HDPE bag and double layered polythene bag in combination with *A. conyzoides* recorded minimum losses of 0.61, 0.94 and 0.37, 0.52, respectively, by both the pests. It was observed that HDPE and DLP bag with *A. conyzoides* recorded lowest adult emergence; lowest grain damage and weight loss compared to other treatments. Very few *S. oryzae* adults were survived on treated maize. The parent weevils were unable to reproduce on the treated maize, multiplication of insect pests was hampered or the larvae died sometime during the developmental stage. This is because the respiratory activities of the weevils and the grain itself leads to the depletion of O_2 and a build up of CO_2 in the sealed bags resulting in asphyxiation and eventual mortalities of the weevils thereby reducing or truncating damage. The packing materials without botanical also recorded lowest survival, low adult emergence, minimum grain damage and weight loss compared to control for both the pests. Maximum progeny emergence, grain damage and grain weight loss was observed in cloth bag (control) which might be due to lack of air tightness and absence of plant powder. As a result the insects were able to multiply in large numbers within short period of time.

De Groote *et al.* (2013) studied the effectiveness of hermetic systems in controlling maize storage pests in Kenya and found that metal silos are very effective in controlling maize weevils and the larger grain borer. Anankware *et al.* (2012) studied the efficacy of the multiple layer hermetic storage bag and found effective against *Prostephanus truncatus* and *Sitophilus zeamais* of stored maize. Quezada *et al.* (2006) reported 100 per cent mortality of *P. truncatus* after a few days when maize grain stored in glass containers. Seck *et al.* (1996) reported the use of hermetic storage in combination with *Boscia senegalensis* fruits at 1.2 g/l (flask volume) reduced the emergence of the cowpea beetle, while 2.4–4.8 g/l completely inhibited the production of a new generation of *Callosobruchus maculatus*. Prolonged storage durations increased adult mortality, significantly increased the developmental time and induced 60–80 per cent reduction in the F_1 progeny. Muda (1984) reported that mixing of neem leaves with paddy grain in a proportion of 2 to 100 parts (wt/wt), bag treatment with 2 per cent neem leaf water extract (wt/wt), or placing barriers of neem leaves between bags and storage floor, significantly reduced the infestation by *S. oryzae* and *R . dominica* and damage to paddy grain stored in 40 kg jute bags for 3 months. It was noted that even under heavy artificial infestation, if the maize is properly dried, damage and loss for the first three months are relatively small (De Groote *et al.*, 2013).

Conclusion :

The present study confirmed that high density polythene bag followed by double layered polythene bag treated with *A. conyzoides* are most effective in controlling *S. oryzae* and *S. cerealella.* It is technically feasible to control maize storage pests without insecticides by using enhanced Hermetic storage system in combination with botanical. The effectiveness of these packing materials without insecticides contributes to the trend to reduce pesticide use and kept storage losses within acceptable levels.

Acknowledgement :

The authors are thankful to Project Director, Directorate of Maize Research, New Delhi for supporting the study.

LITERATURE CITED

Anankware, P.J., Anankware, A.O., Fatunbi, K., Afreh-Nuamah, D., Obeng-Ofori and Ansah, A.F. (2012). Efficacy of the multiple-layer hermetic storage bag for biorational management of primary beetle pests of stored maize. *Acad. J. Entomol.*,**5** (1):47-53.

Andrews, A.S., Annis, P.C. and Newman, C.R. (1994). Sealed storage technology on Australian farms. In: Highley, E. (Ed.), Proceedings of the 6th International Working Conference on Stored-product Protection. 27-36pp.

Birewar, B.R. (1985). Recent development in storage structures. In: *Storage of agricultural durables and semi-perishables*. Central Institute of Agricultural Engineering, Bhopal (M.P.) INDIA.

Boxall, R.A. (2002). Damage and loss caused by the larger grain borer *Prostephanus truncatus. Integ. Pest Mgmt. Rev.*, **7** (2) : 105-121.

Chouksey, R.G. (1985). Bag and bulk storage of food grains at farmers level. In: *storage of agricultural durables and semi-perishables*. Central Institute of Agricultural Engineering, Bhopal (M.P.) INDIA.

De Groote, H., Simon, C., Likhayo, K.P., Fred, K., Tadele, Tefera and Jon, Hellin (2013). Effectiveness of hermetic systems in controlling maize storage pests in Kenya. *J. Stored Prod. Res.*, **53**: 27- 36.

Fields, P.G. and White, N.D.G. (2002). Alternatives to methyl bromide treatments for stored-product insect and quarantine insect. *Annu. Rev. Entomol.*, **47**: 331-359.

Golob, P. (2002). Chemical, physical and cultural control of *Prostephanus truncatus*. *Integ. Pest Mgmt. Rev.*, **7** (4) : 245-277.

Golob, P. and Hanks, C. (1990). Protection of farm stored maize against infestation by *Prostephanus truncatus* (Horn.) and *Sitophilus species* in Tanzania. *J. Stored Prod. Res.*, **26** (4) : 187-198.

Gomez, K.A. and Gomez, A.A. (1984). *Statistical procedures for agricultural research*. (2nd Ed.) Wiley Interscience Publications, NEW YORK (U.S.A.).

Gwinner, J., Harnisch, R. and Muck, O. (1996). Manual on the prevention of post harvest seed losses post harvest project GTZ, D-2000, Hamburg FRG. 294pp.

Heinrichs, E.A., Medrano, F.G. and Rapusas, H.R. (1985). Angoumois grain moth In: Genetic evaluation for insect resistance in rice. International Rice Research Institute, Las Banos, Phillipines. 325-334pp.

Isman, M.B. (2006). Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. *Annu. Rev. Entomol.*, **51**: 45-66.

Muda, A.R. (1984). Utilization of neem as a pest control agent for stored paddy, In: (R.L. Semple and A.S. Frio, eds.), Health and Ecology in Grain Post- harvest Technology. Proceedings 7th ASEAN Technical Seminar on Grain Post- harvest Technology. ASEAN Food Handling Bureau, Manila. 117-128pp.

Musa, A.K., Oyerinde, A.A. and Owolabi, F.O. (2009). Evaluation of the efficacy of mixed leaf powders of *Vernonia amygdalina* L. and *Ocimum gratissimum* Del. against *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). *Acad. J. Entomol.*, **2** (2): 85-87.

Navarro, S. (2006). Modified atmospheres for the control of stored-product insects and mites. In: *Insect management for food storage and processing*, (2nd Ed.) Heaps, J.W. Ed., AACC International, St. Paul, MN. 105-146pp.

Quezada, M.Y., Moreno, J., Vazquez, M.E., Mendoza, M., Mendez-Albores, A. and Moreno-Martinez, E. (2006). Hermetic storage system preventing the proliferation of *Prostephanus truncatus* Horn. and storage fungi in maize with different moisture contents. *Post-harvest Biol. & Technol.* **39** (3) : 321-326.

Sabio, G.C., Dator, J.V., Orge, R.F., Julian, D.D.T., Alvindia, D.G., Miranda, G.C. and Austria, M.C. (2006). Preservation of Mestizo 1 (PSB Rc72H) seeds using hermetic and low temperature storage technologies. In: Lorini, I. *et al.* (Eds.), Proceedings of the 9th International Working Conference on Stored Products Protections Campinas, Sao Paulo, Brazil, ABRAPOS. 946-955pp.

Seck, D., Lognay, G., Haubruge Marlier, M. and Gasper, C. (1996). Alternative protection of cowpea seeds against *Callosobruchus maculatus* using hermetic storage alone or in combination with *Boscia senegalensis* (Pers.) Lam ex Poir. *J. Stored Prod. Res.*, **32** (1) : 39-44.

Sinha, A.K. (1994). Proceedings of 6th International working conference on stored product protection 17-23 April, Canberra, Australia. 1059-1063pp.

Sinha, A.K. (1994). The impact of insect pests on aflatoxin contamination of stored wheat and maize. In: Stored product protection : Proceedings of 6th International working conference on stored product protection. (E. Highley, E.J. Wright, H.J. Banks and B.R. Champ), Eds., 1059-1063pp.

Smith, S.M., Moore, D., Oduor, G.I.,Wright, D.J., Chandi, E.A. and Agano, J.O. (2006). Effect of wood ash and conidia of *Beauveria bassiana* (Balsamo) vuillemin on mortality of *Prostephanus truncatus* (Horn). *J. Stored Prod. Res.,* **42** (3) : 357-366.

Stockel, J. and Turtaut, P. (1970). Rearing technique for mass production of virgin adults of the angoumois grain moth. *Phytoma*, Paris, **22** (219): 17-20.

TEAP (2000). UNEP technology and economic assessment panel (TEAP). Report of the technology and economic assessment panel, April 2000. UNEP, Nairobi.

Yusuf, B.L. and He, Y. (2011). Design, development and techniques for controlling grains post-harvest losses with metal silo for small and medium scale farmers. *African J. Biotechnol.,* **10** (65) : 14552-14561.

6th Year
★★★★★ of Excellence ★★★★★