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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; SP-10(5): 518-522

www.thepharmajournal.com
Received: 17-02-2021
Accepted: 05-04-2021

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Study on effect of triple layer hermetic bags in seed storage system at domestic level

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Abstract
Small and marginal Farmers are getting less income from cereal and pulse crops due to less storage facilities to store grains till the remunerative price attain in market. Storage of grains from field crops is major problem still today in India, due to lack of awareness on storage systems and facilities. Insect pests have been a serious problem threatens the livelihood of small-scale farmers and most commonly found insect was *T. Castaneum, R. Dominica and C. Cephalonica.* Hermetic storage bags are best solution to this farming group to store their grains at depleted oxygen levels and enhanced carbon dioxide levels to prevent growth of insects in grains. In this study storage the grains in Hermetic storage bags and Mesta storage bags for 6 months at 30^0 to 35^0C and 60 to 70% humidity in the YSR district of Andhra Pradesh. Hermetic storage has proven especially effective in hot, humid climates to combat frequent, devastating post harvest losses and prevent the growth of insect pests. Grains stored in hermetic bags showed the better results *i.e.,* germination percentage > 90%, grain weight loss is < 5% and visual damage was nil observed during 6 months of grain storage. Whereas grains stored in Mesta bags reveled unstable results that is germination percent was decreased from 90% to 64%, loss of grain weight is 54% and insect pest damage is 60% was noticed. Hence these hermetic storage bags are more effective and less expensive in grain storage for small and marginal farmers.

Keywords: Germination percentage, grain storage system, hermetic storage bags, Mesta bags, visual damage and weight loss

1. Introduction
Globally, the losses of food grain are 2 billion tons per year. (Ibtimes, 2014) [6]. Food availability and accessibility can be increased by increasing production, improving distribution, and reducing the losses. Thus, reduction of post-harvest food losses is a critical component of ensuring future global food security. Reduction in these losses would increase the amount of food available for human consumption and enhance global food security. A reduction in food loss also improves food security by increasing the real income for all the consumers (World Bank, 2011) [8]. Increasing agricultural productivity is critical for ensuring global food security, but this may not be sufficient. Food production is currently being challenged by limited land, water and increased weather variability due to climate change. To sustainably achieve the goals of food security, food availability needs to be also increased through reductions in the post-harvest process at farm, retail and consumer levels. (FAO, 2013) [4]. India succeeds in record production of food grain. Out of these grain 70 percent are stored at farmers field/house.

There are basically two methods of storage, bag storage and bulk storage. Bags can be stored either in the open air or in ware houses. Bulk grain is stored in bin or silos of various capacities. The choice between these methods and the degree of technological sophistication of the storage buildings depend on many technical, economic and socio-cultural considerations. Based on types, traditional and improved storage structures are used.

India is amongst the leading countries as far as food wastage is concerned. Food grains worth Rs. 58,000 Crore are wasted per annum due to the lack of (or inferior quality) the storage facilities. The poor condition of the food grain is due to the inferior condition of godowns. To increase storage capacity, the National Policy on Handling, Storage and Transportation of Food grains have been prepared. The main objective of the policy is to harness efforts and resources of public and private sectors to build the infrastructure for bulk handling, storage and transportation of food grains in the country.

The storability of the food grain is affected by different factors like, moisture content of the grain, oxygen, carbon dioxide content of the storage environment.

As the moisture content affects food grains storability severely, the storage structures must be provided with sufficient protection from moisture migration to the grain from the environment. The insect and pests grow at a faster rate in the presence of oxygen and moisture in the storage environment. To avoid infestation, the storage environment can be manipulated or a chemical treatment can be given to the grain.

Among the new gaseous application technologies that have successfully replaced fumigants are the manipulation of modified atmospheres (MAs) through the use of bio generated MAs, for insect control and for quality preservation of grains, stored paddy, polished rice, wheat, pulses, cocoa or coffee beans, and pluses grains. The MAs can be achieved either by the natural respiration of the grain and the insects or by artificially flushing of gases. Sufficiently sealed structures generate the MA by reducing the O2 and increasing the CO2 concentrations. The sealed structures keep moisture levels of the grain constant which prevents mould growth. This technology is also termed as sealed storage, airtight storage, or assisted hermetic storage, bio-generated modified atmosphere (MA), etc. Hermetical Storage is based on the principle of generation of an oxygen-depleted, carbon dioxide-enriched atmosphere caused by the respiration of the living organisms in the ecological system of a sealed storage. Among the advantages of hermetic storage, the generation of MA eliminates the need for chemical treatments, fumigants, etc. These structures may help in reduction in moisture migration from the environment to the grain, protection from rodents, reducing losses of germination and vigor of the grain. The triple layer bags consist of a double layer bag of High Density Poly-ethylene (HDPE) bags inside a standard polypropylene woven bags were shown to effectively protected cowpeas against bruchid beetles in West Africa (Baoua, *et.al.*, 2012) [1]. Among the different grains, paddy, red gram, black gram, bengal gram and green gram are the major food grains produced by farmers in YSR Kadapa district and farmers having less storage facilities in this operational area, for overcoming the situation a study was conducted in KVK adopted village for testing the storage of hermetic bags.

2. Materials and Methods

2.1 Hermetic bags

Hermetic bags are obtained from ecology center, Ananthapur, A.P. These bags are designed by improved poly ethylene and woven poly propylene bags with high density and physical strength as well as high impermeability of gases / ambient air. Hermetic bags are made of plastic material which is not a good conductor of heat unlike metallic materials. The basic component of hermetic bags are the inner bags made of high density transparent poly ethylene bags which contains double and single and the outer woven poly propylene material for strength to bare grain weight.

2.2 Germination percentage

Collected the sample of seeds from the bag with three replications randomly. Place these seeds at a suitable spacing on a moistened tissue paper; cover this paper with another moistened tissue paper. Leave the sample at room temperature for seven to eight days. After four to five days the samples should be checked for first count and after seven to eight days for final count removed the sample from paper.

Germination percentage can be calculated by using formula

$$\text{Germination \%} = \frac{\text{Number of seed sprouted}}{\text{Total no. of seeds taken}} \times 100$$

Losses in quantity of the stored produce result from grain being spoilt or running out from damaged bags, or from the grain being damaged by pest organisms. Losses in weight may also result from changes in the grain moisture content during the storage period.

2.3 1000 seed count and weigh method

Test weight is used as an indicator of general grain quality and is a measure of grain bulk density. The 1000 grain weight is a very important measure of seed quality, which is effective on sprouting, seed potential, seedling growth, and plant performance (Hossein Afshari *et al.*, 2011) [5]. Collect 75 – 100 grams of grain from storage bag and separate damaged and undamaged grains. Count number and weigh the sample of damaged grains and undamaged grains separately. Calculate the percent by using the formula given below.

$$\text{Weight loss \%} = \frac{(W_u \times N_d) - (W_d \times N_u)}{W_u \times (N_d + N_u)} \times 100$$

Where

W_u=weight of undamaged grains in gm

N_u=number of undamaged grains in gm

W_D = weight of damaged grains in gm

N_d = number of damaged grains in gm

2.4 Visual Damage Scale

This method involves using a standardized visual damage scale (VDS) which can be developed by following some basic principles (Compton *et al.*, 1998) [2]. A scale based on five levels of damage should be developed. The first level should be first class quality grains and each of the other levels increasing in the proportion of damaged grains. Samples were collected from storage bags by using 1m spear, each sample was taken by inserting the spear into the grain mass straight to the utmost depth, then rotating the tube to make sure that the open compartments filled up with grain, then rotated back to shut the compartments. The spear samples were emptied, on a cloth spread on the bottom. An assessment of every pile of grain was done by visual analysis.

Class A	No damaged grain
Class B	A Small percentage of grains with slight damage, about 20% insect holes
Class C	About 40% of grains damaged, with insect holes, grass and moth weds present
Class D	About 60% of the grains damaged, with insect holes, frass and moth webs present
Class E	About 85% of the grains damaged with insect holes, frass and moth webs present

2.5 Study area and sampling

Farmers were randomly selected from adopted village and distributed hermetic bags with capacity of 40 kg, 25 kg and 10 kg. 40 kg capacity used for paddy storing, 25kg, 10 kg capacity used for pulses at their grain storage rooms having temperature of maximum 35^0 C and minimum 22^0C the experiment conducted after *Kharif* for cereals and Rabi for pulses. The average relative humidity is 60 to 75% respectively. Fortnight visits and monthly sample collection was done and evaluated germination, grain weight, insect infestation and pest incidence during the storage period of 6 months. Qualitative changes occur in the grains as the storage period increases. These losses can occur in various forms like:

- Changes in colour (e.g. yellowing of rice)
- Changes in smell
- Changes in taste
- Loss of germination power in seeds

3. Result and Discussion

Two treatments were taken at farmer's level for test the performance of hermetic storage system and Mesta storage bags. T_1 is farmers practice using of Mesta bags and T_2 is hermetic storage bags. Major cereal (Paddy) and pulses (Green gram, Bengal gram, Black gram and Red gram) were tested in adopted villages of Krishi Vigyan Kendra in the operational areas of YSR district.

3.1 Percent of germination analysis

Pre and post germination analysis was tabulated in table 1 and 2. Germination percentage was gradually decreases collected seeds from Mesta bags and stable in Hermetic bags storage system. Table 1 depicting germination percentage of initial samples of two replications having similar germination percent. Table 2 revealing germination percent of farmer's practice and hermetic storage bags during storage period of 6 months. Germination in paddy from 2nd month to 6th month 18 % in T_1, 2% in T_2. In Red gram T_1 is 25% decreases from 2nd month to 6th month, whereas in T_2 it was very less 5% only. In Black gram 23%, in Bengal gram 29%, in Green gram 19% and in cowpea 23% germination was decreased. In T_2 of all grains around 2 to 5% germination was lost respectively these results confirm with results of Baoua, *et al*., (2012) [1].

Table 1: Initial germination percentage of tested grains (mean)

Germination percentage	T_1 mean	T_2 mean
Pre test for Initial sample (1st month)		
Paddy	95	95
Red gram	95	95
Black gram	92	92
Bengal gram	96	96
Green gram	98	98
Cowpea	94	94

Table 2: Germination percentage of grains during storage of 6 months (Mean)

% Germination	T_1 Mean	T_2 Mean	T_1 Mean	T_2 Mean	T_1 Mean	T_2 Mean	T_1 Mean	T_2 Mean	T_1 Mean	T_2 Mean
Post test	2nd Month		3rd Month		4th Month		5th Month		6th Month	
Paddy	82	94	79	94	76	93	71	93	64	92
Red gram	87	95	85	94	84	92	73	92	62	90
Black gram	82	92	80	92	78	91	67	90	59	90
Bengal gram	83	95	80	94	74	93	68	91	54	91
Green gram	81	96	79	95	70	94	66	93	62	92
Cowpea	80	94	75	93	72	93	64	91	57	90

3.2 1000 Count and weigh method

Collected 30 samples from Hermetic and Mesta bags to analyze the weight of 1000 grains. Based on seed index it was calculated 1000 grains and tabulated in table 3 and loss of weight difference and weights of the samples were tabulated in table 4. Test weight is a general indicator of grain quality and it can be measure the bulk density of grain. Test weight, but not overall grain weight, normally increases during drying. Use of test weight in grain industry it can be used to determine the grain values. Table no. 4 depicts the mean test count weights of samples and percent difference between pre and post test of T_1 (Farmers practice- Mesta storage bags). Very less difference was identified in treatment 2 (Hermetic storage bags) Deivasigamani *et al*., (2007) [3].

Table 3: Initial grain weight of tested grains (Mean)

Grain weight	T_1 Mean	T_2 Mean
Pre test for Initial sample (1st month)		
Paddy	25 g	25 g
Red gram	73 g	73 g
Black gram	42 g	42 g
Bengal gram	185 g	185 g
Green gram	36 g	36 g
Cowpea	94 g	94 g

Table 4: Grain weight and percent weight loss of the samples during storage period (mean)

Grain weight (gm)	T_1	T_1%	T_2	T_1	T_1%	T_2	T_1	T_1%	T_2	T_1	T_1%	T_2	T_1	T_1%	T_2
Post test	2nd month			3rd month			4th month			5th month			6th month		
Paddy (gm)	22	12*	25	19	24*	24	17	32*	24	15	40*	23	13	48*	23
Red gram (gm)	71	03*	73	68	07*	73	67	09*	73	58	21*	70	51	31*	70
Black gram (gm)	39	08*	42	35	17*	41	33	22*	41	27	36*	39	22	48*	38
Bengal gram (gm)	173	07*	185	169	09*	183	167	10*	183	154	17*	181	134	28*	180

Green gram (gm)	31	14*	36	29	20*	35	28	23*	35	24	34*	34	16	56*	34
Cow pea (gm)	90	05*	94	88	07*	93	84	11*	93	73	23*	91	63	33*	90

*T_1%: Farmers practice percent difference of grain weight.

3.3 Visual Damage Scale

Visual Damage Scale method involves using a standardized visual damage scale (VDS) and tabulated the mean values of sample grains. Table 5 initial sample VDS and table 6 showing the results of visual damaged grains. From initial to final analysis. Drastic change was observed in Mesta bag storage system and also observed insect holes in grains. The most commonly found insect was *T. castaneum*, *R. dominica and C. cephalonica*. From the all samples Paddy, Green gram and Bengal gram are affected high than the other grains stored in mesta bags. In hermetic storage bags has proved depleted oxygen level and increased carbon dioxide in atmosphere reduced the insect and pest incidence in grains during the storage period of 6 months. The major insects of each species, mainly *T. castaneum* in green gram, *R. dominica* in Bengal gram and *C. cephalonica* in paddy was observed. These results are close related with Semple *et al*., 1992 reports; stored grain damage level based on type of insect, population, size of pests in the grain and influence of environmental factors like humidity, temperature supports the development of pest.

Table 5: Visual damage of grains by using VDS

Crop	T_1 mean	T_2 mean
Pre-test Initial sample (1st month)		
Paddy	A	A
Red gram	A	A
Black gram	A	A
Bengal gram	A	A
Green gram	A	A
Cowpea	A	A

Table 6: Visual damage of grains by using VDS

Crop	T_1 Mean	T_2 Mean	T_1 Mean	T_2 Mean	T_1 Mean	T_2 Mean	T_1 Mean	T_2 Mean	T_1 Mean	T_2 Mean
Post test	2nd month		3rd month		4th month		5th month		6th month	
Paddy	A	A	B	A	C	A	C	A	C	A
Red gram	A	A	B	A	B	A	C	A	D	A
Black gram	B	A	B	A	B	A	D	A	D	A
Bengal gram	A	A	A	B	C	A	C	A	D	A
Green gram	A	A	B	A	C	A	D	A	D	A
Cowpea	A	A	B	A	B	A	D	A	D	A

T_1: Mesta bags storage (Farmer's practice)

T_2: Hermetic storage

Photo 1: Stored paddy for seed purpose in Mesta and Hermetic bags for 6 months

4. Conclusion

Seed quality was found better in hermetic storage bags, farmers can get the highest benefit using hermetic bags for grain storage. The least amount of storage loss, insect infestation and highest percentage of germination and value addition were obtained in hermetic bags. Field crops grain storage is an open challenges in the developing countries needs urgent attention and commitment, by the farmers to protect grain quality, based on grain quality farmer can enhance their income level even in crisis of less supporting price by the government. Hermetic storage bags sufficiently airtight, modern, transportable, sustainable, chemical free, user friendly, "green" and cost effective solution to storage from Insect infestation; Preventing aflatoxin growth; Preventing rancidity in commodities; Safe, long term storage for quality preservation; Suitable and economic for preservation of seed germination during storage; Eliminating the need for pesticides, fumigants or refrigeration in storage. Introduction of the hermetic storage systems, developing countries can meet their food security requirements, reduce costs, and increase the incomes of their local farmers.

Competing Interests

Authors have declared that no competing interests exist.

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