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Effect of storage duration on germination percentage of green gram (*Vigna radiate* L.) stored in hermetic and other bags

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Abstract
The present paper describes the storage behavior of green gram (*Vigna radiate* L.) stored in different types of storage bags including hermetic bag. Green gram grains were procured from the local market, cleaned and graded by two screen cleaner-cum-grader. Storage study was conducted by storing large sized green gram grains in 4 types of bags (jute, plastic, polythene and hermetic) with and without treatment (aluminium phosphide tablets) at three different initial moisture contents (12.34, 14.07, 16.04 % w.b.). Total 21 such bags having different treatment combinations were kept in laboratory for 33 weeks. Daily observation of ambient temperature and relative humidity was recorded throughout the study period. Weekly observations of moisture content were recorded for 27 (jute bags) to 33 weeks (hermetic bags). It was observed that germination percentage decreased with the increase in storage period in all the 21 experimental combinations. The overall variation range for germination was 81.7 to 1.3%. Variation was more pronounced in case of untreated samples as compared to that of treated samples. Hermetic bags stored green gram was found better with maximum germination uptake even after 33 weeks of storage duration. On the other hand, samples stored in jute bags were found to be severely damaged with heavy infestation of pulse beetle in 27 weeks. Statistical analysis through UNIANOVA revealed that treatment emerged as most significant independent variable to affect germination. The interaction of bags*imc significantly affected germination. Hence the hermetic bag could be recommended for storing green gram safely for longer duration without affecting its quality.

Keywords: Green gram, moisture content, germination percentage, hermetic bags, UNIANOVA

Introduction
Around 65% of India's population is dependent upon agriculture and allied sectors. Various cereals (wheat, rice etc.), pulses (pigeon pea, gram etc.) and oilseeds (groundnut, soybean) are produced largely in India. India is the world's largest producer and consumer of pulses accounting about 27% of the total production and about 30% of total consumption in world.
Post-harvest food Loss (PHL) is defined as measurable qualitative and quantitative food loss along the supply chain, starting at the time of harvest till its consumption or other end uses. Post harvest losses are due to poor production practices, poor post harvest management practices, lack of grading at farm level, poor packaging, poor transportation, multiple handling, and poor marketing system. Reduction of pre-harvest, harvest and post-harvest losses is indeed a complementary means of increasing the food availability. Storage losses are due to high moisture content of the stored material, the storage condition (high relative humidity), erratic climatic condition, absence of primary processing (cleaning and grading) at farm level and lack of storage facility at production catchment. The storage loss in commercial storage of food grains is around 3 to 5% when storage was done for 8 months (Krishnamurthy, 1975) [3].
A method considered for the prevention of storage losses in airtight storage bags termed as 'airtight storage' or 'hermetic storage' bags. Hermetic storage systems strive to eliminate all exchange of gases between the inside and the outside of a grain storage container/bag. If the gas exchange is low enough, living organisms such as insects within the container/bag will deplete oxygen and produce carbon dioxide until they die or become inactive due to the low oxygen.

Hermetic storage bags is a safe, cost-effective storage method that controls insect infestations in addition to preserving the quality of grains, while allowing for pesticide-free, short-term and long-term qualitative and quantitative seed preservation, without refrigeration, maintaining seed vigor and pest control. Storage at low temperature (4°C)ensures greater safety margins between insect development time and break of dormancy, although hermetic storage, even at ambient temperatures, naturally eliminates insect development altogether. Hermetic storage is capable of maintaining relative humidity that preserves seed moisture and prevents mold growth. Hermetic bags need to be validated for its effectiveness in hermetic storage of food grains under Bihar conditions.

Materials and Methods

Sample preparation and treatment

Fresh and healthy green gram pulse grains were procured from local farmer at Ratwara village of Muzaffarpur district in Bihar. Cleaning and grading of grains was done in two screen seed cleaner-cum-grader using top screen of 4.0 mm and bottom screen of 2.5 mm round holes. Total 210 kg cleaned and graded green gram grains of 2.64 mm Ø size with moisture content of 12.05% w.b. were available for storage study. Grains were weighed on a digital platform type balance (WENSER) having 150 kg capacity and 0.01 kg sensitivity.

The fumigant (Aluminium Phosphide) popularly known as sulphas was used for the chemical treatment whose molecular formula is AlF, molecular weight is 57.955 gm.mole^{-1} and density is 2.85 gm.cm^{-3}. Half sulphas tablet weighing 0.93 g kept inside a piece of muslin cloth was placed in the centre of the bag and bag-mouth was closed by tightly twisting the free portion and then tying it by plastic rope.

Experimental Variables

Independent variables

1. Type of storage bags : 4 types [Jute (JUT), Plastic (PLS), Polythene (PLY), Hermetic (HER)]
2. Initial moisture content(IMC) % w. b. : 3 levels [IMC1-12.32%, IMC2-14.04%, IMC3-16.04% w.b.]
3. Treatment : 2 levels [Treated chemically (T), Untreated (UT)]
4. Storage duration (weeks) : 28 to 34 levels [Jute bags – 0 to 27 weeks, Plastic bags 0 to 29 weeks, Polythene bags 0 to 31 weeks, Hermetic bags 0 to 33 weeks]

Dependent variables

- Germination, %

Observations

- Ambient temperature ºC (Daily)
- Ambient R.H.,%(Daily)

Experimental design

Factorial -4 types of bags × 2 types of treatment × 3 levels of IMC = 24 Combinations

But the Hermetic bags were used to store samples without any treatment only, so the total combination reduced to 21 as detailed below:

• 3 JUT bags – T – with IMC_1, IMC_2, IMC_3	• 3 JUTbags – UT – with IMC_1, IMC_2, IMC_3
• 3 PLY bags – T – with IMC_1, IMC_2, IMC_3	• 3 PLY bags – UT – with IMC_1, IMC_2, IMC_3
• 3 PLS bags – T – with IMC_1, IMC_2, IMC_3	• 3 PLS bags – UT – with IMC_1, IMC_2, IMC_3
	• 3 HER bags – UT – with IMC_1, IMC_2, IMC_3

Experimental Methodology

After determining moisture content of cleaned and graded lot of green gram grains as 12.05 % w.b., the whole lot was subdivided in three sub-lots. Required amount of water was added in two sub-lots which were left for tempering for 24 hours to adjust the moisture within the grain heap for getting two more desired levels of moisture contents. The initial moisture content of all three lots was determined again which were found as 12.34%, 14.07%, 16.04 % w.b. Then green gram grains were stored in 21 bags as per experimental design. The size of hermetic/polythene bag was 112×61 cm, and of jute/plastic was 83×55 cm (having capacity of 50 kg each). For treatment of samples, half tablet (0.93g) of sulphas tied in a small piece of muslin cloth was kept in stored grains. The mouth of each bag was tied with the help of plastic rope after evacuating air above the stored grains out of the bag. For observations, samples were drawn from each bag randomly every week. Observations were continued for 27-33 weeks for different bags depending upon the condition of resultant grains.

Determination of moisture content

The moisture content of sample was determined by standard hot air oven method. The samples were dried in hot air oven at 105±2ºC for 24 hours. The moisture content of sample was determined in accordance with AOAC method (Anonymous, 1990) using following formula:

$$MC=\frac{w_m}{w_{m+w_d}} \times 100$$

Where

MC =Moisture content, % w.b.

W_m =Weight of the moisture evaporated, g

W_d= Weight of dried sample, g

Determination of germination percentage

100 grains of green gram were taken in trays fully filled with wet sand. Water spraying was done regularly to keep the grain moist. After a time of 72 hours, germination of grains was counted carefully and germination percentage of samples was determined.

Recording of observations

The ambient temperature and relative humidity were recorded by portable digital temperature/relative humidity meter (ZEAL, 0.1ºC, 0.1%). Observations were taken on daily basis during entire period of experimental storage in near vicinity of storage bags.

Results & Discussion

The summarized overall variation in germination percentage with minimum and maximum values under each experimental combination have been presented in Table 1. It reveals that the germination of the grain was initially in the range of 64.0 to 81.7% for three initial moisture contents (IMC) which went down in the range of 1.3 to 32.0% after 33 weeks of storage. The lowest germination value was observed as 1.3% for the experimental combinations of JUT/UT/IMC1. The germination of untreated Green gram grain in the jute bag was decreased from 81.7 to 1.3% across all IMCs after 27 weeks of storage. Similarly germination of treated Green gram grain in the jute bag was decreased from 81.7 to 1.8% across all IMCs after 27 weeks of storage. The germination of untreated Green gram grain in the hermetic (HER) bag was decreased from 81.7 to 24.0% across all IMCs after 33 weeks of storage. The decrease in germination with storage period may be due to increase in moisture content owing due to variation in temperature and relative humidity during storage period. Germination was drastically reduced towards the end weeks due to heavy infestation of pulse beetle (*Callosobruchus chinensis*). These results are in line with results of previous researchers – Mutungi *et al*. (2014) [5], Kumari*et al*. (2015) [4] and Kumar *et al*. (2016) [1] for other grains.

Table 1: Summarized overall variation in germination for all experimental combinations

Treatment Combination	Max. Value (week no)	Min. Value (week no)
JUT/T/IMC1	81.7 (0)	1.8 (27)
JUT/UT/IMC1	81.7 (0)	1.3 (27)
PLS/T/IMC1	81.7 (0)	2.6 (29)
PLS/UT/IMC1	81.7 (0)	2.3 (29)
PLY/T/IMC1	81.7 (0)	2.7 (31)
PLY/UT/IMC1	81.7 (0)	2.5 (31)
HER/UT/IMC1	81.7 (0)	32.0 (33)
JUT/T/IMC2	71.7 (0)	2.0 (27)
JUT/UT/IMC2	71.7 (0)	2.3 (27)
PLS/T/IMC2	71.7 (0)	3.0 (29)
PLS/UT/IMC2	71.7 (0)	3.0 (29)
PLY/T/IMC2	71.7 (0)	4.2 (31)
PLY/UT/IMC2	71.7 (0)	4.0 (31)
HER/UT/IMC2	71.7 (0)	27.0 (33)
JUT/T/IMC3	64.0 (0)	2.7 (27)
JUT/UT/IMC3	64.0 (0)	3.0 (27)
PLS/T/IMC3	64.0 (0)	4.0 (29)
PLS/UT/IMC3	64.0 (0)	3.8 (29)
PLY/T/IMC3	64.0 (0)	5.0 (31)
PLY/UT/IMC3	64.0 (0)	5.2 (31)
HER/UT/IMC3	64.0 (0)	24.0 (33)

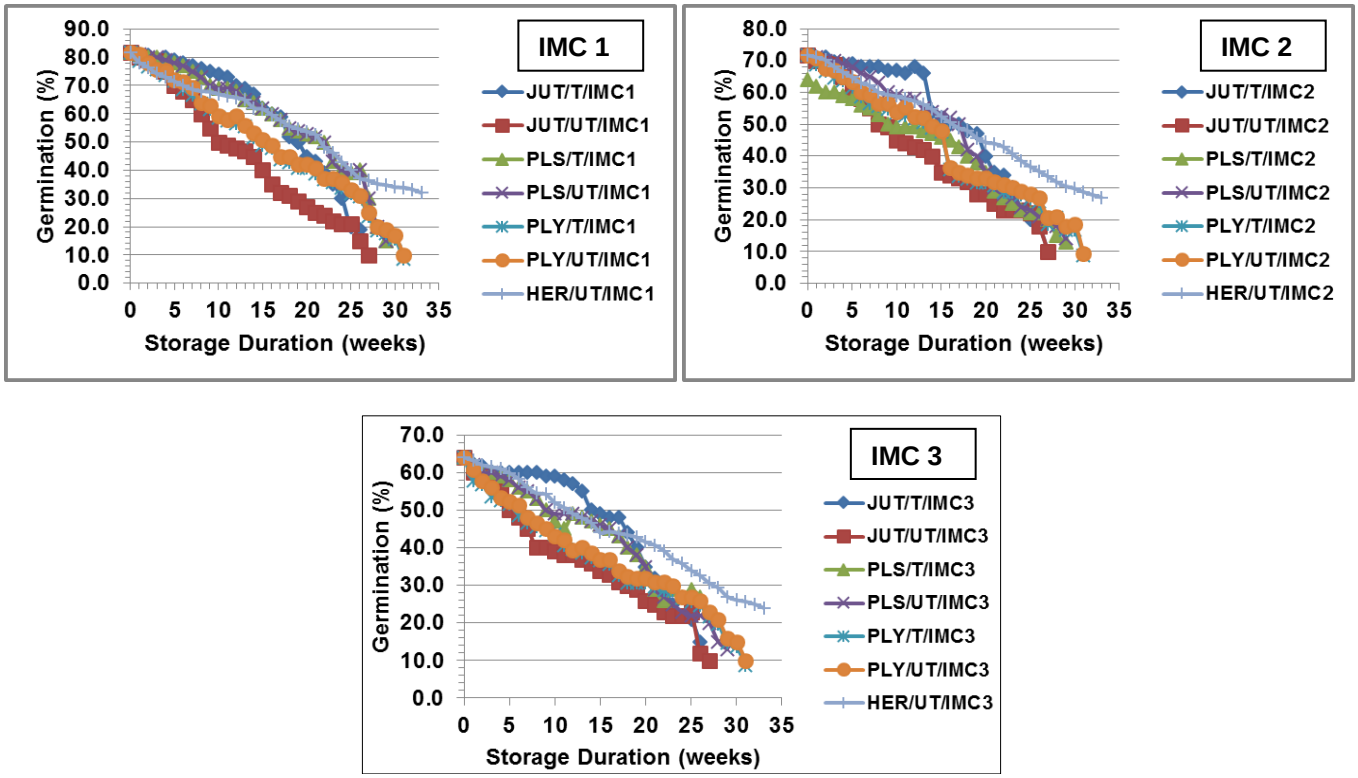

Fig 1: Variation in germination with storage duration for different bags and treatment at three different initial moisture contents

Germination had a general increasing trend across all experimental combinations with advancement of storage duration (Fig. 1). Fig. 1 is showing the variation in germination with storage duration for different bags and treatment at three different IMCs. The germination had a general decreasing trend across all experimental combinations with advancement of storage duration. Untreated Green gram grains stored in HER bags had higher germinations across all IMCs compared to PLY bags, PLS bags and JUT bags in that order. Similarly treated grains behaved in the same manner across all combinations. The germinations were lowest at IMC1 as compared to IMC3 at all experimental combinations.

Table 2: UNIANOVA for effect of independent variables on germination

Source	Type III Sum of Squares	df	Mean Square	F	Sig.<0.05%
Corrected Model	95.768[a]	641	.149	63.660	.000
Intercept	382.440	1	382.440	1.630E5	.000
Bags	3.660	3	1.220	519.789	.000
Trt	.009	1	.009	3.767	.052[ns]

Imc	15.332	2	7.666	3.266E3	.000
Week	61.313	33	1.858	791.669	.000
bags * trt	.009	2	.004	1.812	.164[ns]
bags * imc	4.627	6	.771	328.586	.000
bags * week	.756	87	.009	3.702	.000
trt * imc	.221	2	.110	47.032	.000
trt * week	.099	31	.003	1.364	.089[ns]
imc * week	.984	66	.015	6.351	.000
bags * trt * imc	.334	4	.083	35.546	.000
bags * trt * week	.344	56	.006	2.618	.000
bags * imc * week	1.056	174	.006	2.586	.000
trt * imc * week	.166	62	.003	1.144	.212[ns]
bags * trt * imc * week	.364	112	.003	1.385	.007
Error	3.006	1281	.002		
Total	535.194	1923			
Corrected Total	98.774	1922			
R Squared = .970 (Adjusted R Squared = .954) ns = non-significant					

Table 2 shows UNIANOVA for main factors effect and their interaction effect on germination for the entire experiment. It reveals that bags, imc, weeks, and all interactions except three had a significant effect on germination. The imc having highest F-value affected germination the most followed by weeks, bags and trt. The interaction of bags*imc was the most important interaction which affected germination the most. Among main effects the trt had a non-significant effect.

Conclusion

The germination had a general decreasing trend across all experimental combinations with advancement of storage duration. Untreated Green gram grains stored in HER bags had higher germinations across all IMCs compared to PLY bags, PLS bags and JUT bags in that order. Similarly treated grains behaved in the same manner across all combinations. The germinations were lowest at IMC1 as compared to IMC3 at all experimental combinations. The hermetic bags performed better allowing maximum germination uptake as compared to other types of bags. Hence the hermetic bags could be recommended for storing green gram safely for longer duration without affecting its quality.

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