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Influence of packaging materials on storability of groundnut (*Arachis hypogaea* L.)

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Abstract
A laboratory experiment was conducted at Department of Seed Science and Technology, College of Agriculture, Bheemarayangudi, UAS, Raichur to know the influence of specialized packaging material on storability of groundnut. In this experiment the freshly harvested seeds of K-9 variety groundnut kernel and pods were stored in specialized packing material of super grain bag, purdue improved crop storage(PICS) bag and polylined (700 gaues) gunny bags (PLGB) with (4) replication. The results revealed that, pods stored in PICS bags recorded significantly higher germination percentage (90.0 %), shoot length (6.0 cm), root length (18.3 cm), seedling vigour index (2130), seed infection (2.61%), no seed infestation and moisture content (7.03%) at initial month of storage whereas after nine months of storage it was observed that germination percentage was (78.0 %), shoot length (3.3 cm), root length (11.8 cm), seedling vigour index (1173), seed infection (28.03%), seed infestation (13.05%) and moisture content (6.41%). Both kernel and pods which are stored in PICS bag showed best result compared to other bags. Compared to kernel and pods storage, pods showed best result due to kernel is protected by shell and seed coat kernel is very delicate so that embryo loss is more hence, seed quality parameter affected. In packaging material PICS bag is a three layer hermitic storage bag which is air tight moisture impervious bag compared to other bags. From these results it can be concluded that PICS bag when found best storage bag for groundnut pods then that of other bags.

Keywords: groundnut, packaging materials, seed forms and Seed quality parameter

Introduction
Groundnut [*Arachis hypogaea* (L.)], "king of oil seed crops" is believed to be native of Brazil (South America). Groundnut is also called as wonder nut and poor men's cashew nut. Groundnut is one of the most important cash crops of our country. It is a low-priced commodity but a valuable source of all the nutrients. It belongs to family Fabaceae (also known as Leguminosae) and sub family Papilionaceae. Groundnut is one of the important legume crops of the tropical and semi-arid countries, where it provides a major source of edible oil and vegetable protein (Vavilov, 1961) [14]. The cultivated form of groundnut has been classified into two major groups *viz.,* Valentia or Spanish type *(Arachis hypogaea* sub spp. *fastigiata*) and Virginia type (*Arachis hypogaea* sub spp. *hypogaea*).
Groundnut is one of the poor storer. Storing seeds after harvest till the next cropping season without impairing the quality is of prime importance for successful seed production. Being an oil seed crop groundnut seed has short life and looses viability quickly under ambient conditions. Ageing in groundnut seed leads to increased lipid peroxidation, decreased activities of several free radical and peroxide scavenging enzymes (Rao *et al.,* 2006) [11]. Groundnut seeds are more sensitive to storage conditions like high temperature; high seed moisture content and light exposure. The qualitative loss of seed can be attributed to biochemical changes in protein, carbohydrates, fatty acids and vitamins. The rate of ageing mainly depends on genotype, moisture and temperature. In rapid and slow ageing (natural ageing), the pattern of deterioration proceeding the death is the same whether seed survives for few hours or decades.

Material and Methods
The storage experiment was conducted in the department of Seed Science and Technology, College of Agriculture, Bheemarayanagudi, University of Agricultural Sciences, Raichur, which is located in North- Eastern Dry Zone (Zone 2) of Karnataka at 16º 43 ' N latitude and 76º 51' E longitude with an altitude of 412 above mean sea level (AMSL). The experiment was conducted during the period of July 2016 to June 2017.The experiment involved storage of summer groundnut of variety K-9 to study the "Influence of packaging materials on storability of groundnut (*Arachis hypogaea* L.)".

All the seed quality parameters were observed at monthly interval up to 9 months from the starting period of storage. The details of the materials used and methods adopted for the conduct of various experiments.

This experiment consisted of six treatment combinations involving three different packaging materials *viz.*, P_1: Super grain bag, P_2: PICS bag, P_3: PLGB bag (700 gauge) and Groundnut variety K-9 is stored as both pod and kernel.

Standard germination test

The germination test was conducted by employing between paper method as prescribed by ISTA (Anon., 2012) [4]. Seeds were allowed to germinate in rolled towel in a germinator maintained at 25 ± 2 ºC and RH 95 per cent. The standard germination counts were taken on 5th day and 10th day as first and final count. Total germination percentage was calculated on the basis of number of normal seedlings obtained in the final count expressed in percentage (%).

$$\text{Germination (\%)} = \frac{\text{Number of normal seedling obtained on final count}}{\text{Number of seed put for germination}} \text{ X } 100$$

Seedling vigour index

Seedling vigour index was calculated by adopting the formula suggested by Abdul- Baki and Anderson (1973) [1] as:

Vigour index = Germination (%) X [Root length (cm) + Shoot length (cm)]

Seed mycoflora (%)

The seed health was determined by blotter test to detect the presence of seed borne fungi of groundnut seeds (Anon., 1999) [2]. Three layers of blotter papers (size fitting to the size of petri dish) soaked in sterilized distilled water was placed in petri dish. Ten seeds were placed in each petri dish and the petri dishes were kept in an incubator at 25 ± 1 ºC for 7 days beneath near ultraviolet light with a cycle of 12 hrs. light and 12 hrs. darkness. Four replications were maintained. The seeds were examined on 8th day under stereoscopic binocular microscope. The fungi were identified on the basis of sporulation and their fruiting structures *viz, Aspergillus flavus, A. niger* and *Alternaria* spp., on seed surface. A count of germinating seeds as well as fungal colonies on seeds was taken and expressed in percentage infection.

Seed damage (%)

For working out the seed damage (%), seeds were taken in 50 ml beaker in four replicate from each treatment on monthly intervals. From this sample the seeds with either single or multiple pin hole damages were considered as infested seeds and expressed in percentage.

$$\text{Seed infestation (\%)} = \frac{\text{Number of seeds infested}}{\text{Number of seeds in 50 ml beaker}} \text{ x } 100$$

Seed moisture

Seed moisture content per cent was determined by using low constant temperature method as per (Anon., 2010) [3]. Five grams of seed sample was taken at random from each treatment in two replications, ground and dried in oven at 103 ± 1 ^{0}C for two hours. The seed moisture content was determined by using the following formula and it was expressed on wet weight basis.

$$\text{Moisture content (\%)} = \frac{M2 - M_3}{M2 - M_1} \times 100$$

Where, M_1 - Weight of the container without seed

M_2 – Weight of the container + seed before drying

M_3 – Weight of the container + seed after drying

The observations on germination test were recorded as per the standard procedures. The mean data of the experiment were statistically analyzed by adopting appropriate statistical methods as outlined by Panse and Sukhatme (1978) [9]. The critical differences were calculated at five per cent level was found significant for various germination test parameters under study.

Results and Discussion

In the present study, all the seed quality parameters declined with the advancement of storage period. in all the seed quality parameters. Among the packaging materials, better seed quality parameters *i.e.*, higher germination percentage, root length, shoot length, seedling vigour index, seedling dry weight, (71.00 %, 9.50 cm, 2.79 cm, 888.58, 233.78 mg, respectively) were noticed in the seeds stored in PICS (Purdue Improved Crop Storage) bag. Whereas, the lowest (66.63 %, 8.30 cm, 2.53 cm, 762.82, 223.65 mg, respectively) was noticed in the seeds stored in PLGB bag at the end of nine months of storage period (Table 1 and 2).

In the present study, germination percentage, root length, shoot length, seedling vigour index, seedling dry weight and field emergence reduced progressively with the advancement of storage period irrespective of containers. Significantly higher values for all these quality parameter was recorded in Perdue improved crop storage (PICS) bag. This might be the fact that PICS bag acts as a hermatic storage which works on the principle of creating airtight conditions in which oxygen levels are lowered through insect, fungal and seed respiration, which maintains the seed quality parameters. While, the seeds stored in gunny bag recorded lower values that could be attributed to fluctuation of moisture content, leading to a faster deterioration in seeds. These findings are in agreement with Sudini *et al.* (2014) [12] in groundnut, Patra *et al* (1998) [10], Basavegowda and Ravikumar (2001) [5], Vasudevan *et al* (2014) [13] in groundnut.

The mean lowest seed infection and seed infestation was noticed in seeds stored in PICS bag (25.38 %, 11.83 %, respectively), while it was highest in the seeds packed in PLGB bag (29.95 %, 14.04 %, respectively) at the end of storage period. This is mainly due to the fact that PICS bag act as a hermatic storage container creating airtight condition with low level of oxygen leadig to less insect and pathogen activity. Whereas the seeds stored in PLGB bag lead to attack of insects and pathogen which in turn reduced the seed infection and seed infestation. These results are in conformity with Sudini *et al.* (2014) [12] in groundnut (Table 3 and 4).

Among the packaging materials, the mean lowest moisture content of 6.31 per cent was seen in the seeds stored in PICS bag, whereas highest moisture content of 6.50 per cent was seen in seeds stored in PLGB bag. The high seed moisture content might have caused higher respiration and increased activity of storage fungi, that might have led to poor

storability of seeds stored in moisture pervious container like gunny bag. Whereas, seeds stored in impervious containers like PICS bag Triple layer (that comprises of two inner high density polyethylene bags and one outer woven polypropylene bag) in (Table 4).

As groundnut is a bulky crop with high seed rate requiring larger storage area, hence an attempt was made to reduce the bulkiness and store them in kernel form to evaluate their viability compared to pod. As the storage period advanced, irrespective of form (pod/kernel) groundnut loose its viability and vigour. The groundnut stored as pod retained their viability and vigour comparatively higher than kernel. Superior storability of pod may be due to protection by the shell to the seed (kernel) and act as buffer to prevent absorption of moisture (Baskin, 1979) [6]. Similar results showing the superiority of pod over kernel during storage were reported by Deshpande (1988) [7] in groundnut.

Groundnut stored both in the form of pod and kernel in different packaging materials showed significantly higher germination percentage, root length, shoot length, seedling vigour index, seedling dry weight, (69.67 %, 9.12 cm, 2.68 cm, 856.02, 230.13 mg, respectively) in the form of pod compared to the kernels at the end of storage period. (67.83%, 8.42 cm, 2.39 cm, 806.21, 227.73 mg, respectively) in (Table 1 and 2).

Significantly mean lower moisture content was noticed in the seeds stored in the form of pod (6.32 %) compared to kernel (6.50 %). Similarly the mean lowest seed infection and seed infestation (27.72 %, 12.85 %, respectively) was recorded in groundnut stored in the form of pod, whereas the highest seed infection and seed infestation (28.34 %, 13.24 %, respectively) was noticed in kernel form at the end of storage period. Similar findings were also reported by Gidaganti (1990) [8] in cowpea (Table 3 and 4).

There was no significant difference with the interaction between packaging materials and seeds on seed quality parameters during storage.

Table 1: Effect of packaging materials and seed on germination (%) and root length (cm) of groundnut cv. K-9

Treatments	Months after storage											
	Germination						Root length					
	Initial			9			Initial			9		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
P_1	90.00	90.00	90.00	67.25	70.00	68.63	17.75	17.90	17.83	8.10	8.90	8.50
P_2	90.25	90.50	90.38	70.25	71.75	71.00	18.00	18.28	18.14	9.15	9.85	9.50
P_3	89.50	90.25	89.88	66.00	67.25	66.63	18.53	18.98	18.75	8.00	8.60	8.30
Mean	89.92	90.25	90.08	67.83	69.67	68.75	18.09	18.38	18.24	8.42	9.12	8.77
Factors	SEm±	CD at 1%		SEm±	CD at 1%		SEm±	CD at 1%		SEm±	CD at 1%	
S	0.56	NS		0.32	1.32		0.18	NS		0.16	0.63	
P	0.68	NS		0.40	1.62		0.22	NS		0.19	0.78	
S×P	0.97	NS		0.57	NS		0.31	NS		0.27	NS	

Legend: Seed (S): S_1-Kernel, S_2-Pod,
Packaging materials (P): P_1- Super grain Bag, P_2- PICS Bag, P_3- PLGB Bag.

Table 2: Effect of packaging materials and seed on shoot length (cm) and seedling dry weight of groundnut cv. K-9

Treatments	Months after storage											
	Shoot length						Seedling dry weight					
	Initial			9			Initial			9		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
P_1	6.25	6.10	6.18	2.40	2.73	2.56	398.70	397.70	398.20	228.08	230.65	229.36
P_2	5.98	5.80	5.89	2.63	2.95	2.79	398.70	398.28	398.49	232.35	235.20	233.78
P_3	5.90	6.00	5.95	2.15	2.35	2.25	397.38	397.73	397.55	222.75	224.55	223.65
Mean	6.04	5.97	6.00	2.39	2.68	2.53	398.26	397.90	398.08	227.73	230.13	228.93
Factors	SEm±	CD at 1%		SEm±	CD at 1%		SEm±	CD at 1%		SEm±	CD at 1%	
S	0.12	NS		0.05	0.20		0.32	NS		0.43	1.71	
P	0.15	NS		0.06	0.25		0.40	NS		0.52	2.11	
S×P	0.21	NS		0.09	NS		0.56	NS		0.74	NS	

Legend: Seed (S): S_1-Kernel, S_2-Pod,
Packaging materials (P): P_1- Super grain Bag, P_2- PICS Bag, P_3- PLGB Bag.

Table 3: Effect of packaging materials and seed on seedling vigour index and Seed infection (%) of groundnut cv. K-9

Treatments	Months after storage											
	Seedling vigour index						Seed infection					
	Initial			9			Initial			9		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
P_1	2137	2070	2103	804	879	841	2.50	2.50	2.50	29.00	28.53	28.76
P_2	2075	2156	2115	862	914	888	2.50	2.50	2.50	25.50	25.25	25.38
P_3	2096	2249	2172	751	773	762	2.75	2.90	2.83	30.53	29.38	29.95
Mean	2103	2158	2131	806	856	831	2.58	2.63	2.61	28.34	27.72	28.03
Factors	SEm±	CD at 1%		SEm±	CD at 1%		SEm±	CD at 1%		SEm±	CD at 1%	
S	37.67	NS		12.02	48.94		0.09	NS		0.10	0.39	
P	46.14	NS		14.73	59.94		0.11	NS		0.12	0.48	
S×P	65.25	NS		20.82	NS		0.15	NS		0.17	NS	

Legend: Seed (S): S_1-Kernel, S_2-Pod,
Packaging materials (P): P_1- Super grain Bag, P_2- PICS Bag, P_3- PLGB Bag.

Table 4: Effect of packaging materials, seed forms on seed infestation (%) and moisture content (%) of groundnut cv. K-9

Treatments	Months after storage											
	Seed infestation						Moisture content					
	Initial			9			Initial			9		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
P_1	00	00	00	13.43	13.13	13.28	7.04	7.03	7.03	6.53	6.30	6.41
P_2	00	00	00	11.90	11.75	11.83	7.03	7.03	7.03	6.38	6.25	6.31
P_3	00	00	00	14.40	13.68	14.04	7.04	7.04	7.04	6.60	6.40	6.50
Mean	00	00	00	13.24	12.85	13.05	7.03	7.03	7.03	6.50	6.32	6.41
Factors	SEm±		CD at 1%	SEm±		CD at 1%	SEm±		CD at 1%	SEm±		CD at 1%
S	00		NS	0.09		0.37	0.00		NS	0.03		0.12
P	00		NS	0.11		0.45	0.00		NS	0.04		0.15
S×P	00		NS	0.16		NS	0.01		NS	0.04		NS

Legend: Seed (S): S_1-Kernel, S_2-Pod,
Packaging materials (P): P_1- Super grain Bag, P_2- PICS Bag, P_3- PLGB Bag.

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