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Efficiency of Storage Device for Long term Storage of Cowpea Seeds

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Abstract

A study was conducted for the assessment of an appropriate storage device for long term storage of cowpea seeds. Cowpea seeds were stored in four different containers *viz*. tin container, polythene bag, earthen pot and gunny bag for six months at room temperature. Samples were taken out at monthly interval beginning from the first month of storage to determine the moisture content, germination percentage, vigor index and different fungi associated during storage. The seed moisture content and prevalence of fungi associated during storage were found highest in gunny bag resulting in lowest germination percentage and vigor. Fungal contamination and moisture content increased and seed germination and vigor decreased with the increase in storage period. But seeds stored in tin container maintained excellent germination percentage and vigor index as the moisture content and fungal contamination were less compared to other storage devices throughout the storage period. Comparing all the storage devices, it was found that tin container is the best and secure device for long term storage of cowpea seeds.

Highlights

- Assessment of appropriate storage device for long term storage of cowpea seeds was carried out under *in vivo* condition.
- Four different devices *viz.* tin container, polythene bag, earthen pot and gunny bag was used for the study and cowpea seeds were stored in the devices for six months.
- Among the storage devices, tin container was found best for storage of cowpea seeds followed by polythene bag, earthen pot and gunny bag.

Keywords: Storage, seed quality, seed moisture, storage fungi, *Vigna ungiculata*.

Cowpea (*Vigna unguiculata* L.) is one of the most important annual food crop grown mainly as pulse, vegetables and fodder (Ushamalini *et al.*, 1998). It is mainly consumed as a foodstuff in the form of dried seed. Cowpea grains make major nutritional contributions to diets. The mature grain contains 24.8% protein, 50-67% starch, vitamin-B and essential micronutrients such as iron, calcium and zinc. As the cowpea seed having valuable nutritional

source, therefore their quality maintenance in storage is essential.

Maintenance of seed quality of cowpea in storage from the time of production until the seed is planted is a great challenge for seed growers. Under such circumstances the question is how to manage the seeds to maintain their quality (viability and vigor) throughout the storage period. Generally seeds maintain their quality under favorable storage conditions for longer periods of time than if stored under poor conditions, e.g., high temperature and relative humidity. A question that is frequently asked is whether good storage conditions enhance the quality of the seed? The answer is no. However, the quality of seeds can be maintained and the rate of seed deterioration can be slowed down by good storage environment. Once seeds deteriorate, their physiological quality cannot be restored because seed deterioration is inexorable and irreversible process, just like aging.

The extent and speed of drop in seed quality is largely dependent on the storage temperature, relative humidity, seed moisture content, length of storage, kind of seeds, initial seed quality, physical and chemical composition of seed, gaseous exchange, storage structure and packaging materials (Raikar *et al*., 2011). Around 10-15% production was found reduced due to use of poor seed quality (Huda, 2001). In India, a major part of seed deteriorates at time of storage because most of the farmers do not know how to store seed. They store their seeds as they store their food grain. Seed storage and retention of seed viability always an important consideration in agricultural practice. Poor storage conditions greatly affect seed vigor (Heydecker, 1979). The deterioration rate depends on storage condition i.e. temperature, relative humidity, seed moisture, types of storage container etc. Types of container also regulate temperature, relative humidity and seed moisture contents.

As the seed is hygroscopic in nature, seed quality is affected by variation in moisture content, relative humidity and temperature. To combat these factors, it is better to store the seeds in moisture vapor proof containers to maintain the quality for longer period. The viability and vigor of seeds are also known to be regulated by variations in storage containers, initial seed quality, packaging conditions, physiochemical factors etc. (Doijoide, 1988). Storing the seeds in moisture vapor proof container is found more useful in maintaining the desired seed quality for longer period unlike non moisture proof containers like cloth bag (Singh and Singh, 1992). On the other hand, type of storage container and storage temperature can play a dominant role in maintaining seed viability and vigor of the seeds (Mostrain *et al*., 2012).

Legume seeds are prone to fungal penetration and successive mycotoxin contamination (Ahmad and Singh, 1991; El-Kady *et al.*, 1991; Saber and Aboul-Nasr, 1998). Genera of mycotoxigenic fungi are mainly represented by *Aspergillus, Penicillium* and *Fusarium* (Amadi and Adeniyi, 2009). They are known to produce mycotoxins during storage (Moss, 1989). However, reports on mycotoxins associated with stored cowpea seeds are mainly refer to *Aspergillus* infection associated with aflatoxin production (Hitokoko *et al.*, 1981; Seenappa *et al.*, 1983; El-Hag and Morse, 1976; El-Kady *et al.*, 1996). Aflatoxin is the most popular and widespread mycotoxin. It was found to be produced by *Aspergillus flavus* (Ghadeer *et al.*, 2012).

Conductive growth of fungi takes place during storage due to lack of storage facility and good packaging materials. These factors provide proper environment for successful establishment of fungi on food commodities. During storage, cowpea grains have shown lesser susceptibility to fungal infection (Houssou *et al.*, 2009). As fungi are serious parasites of stored grains, therefore their encroachment can results severe damage like decrease germinability, discoloration of the embryo, heating and mustiness, loss in weight etc. (Banyam, 1987). In addition, fungi can break the tissue of the foodstuff that results to create bad taste and decrease nutritious value. Therefore, any method of storage, which is aimed at preventing or retarding the invasion of these fungi and creating unfavorable conditions for their growth and multiplication will help in improving the quality of seed.

The present study was, therefore, undertaken with the objective to determine the role of different storage containers on various seed quality characters (germination and vigor) and prevalence of storage fungi of cowpea during long term storage.

Materials and Methods

Four types of storage devices *viz.*, tin container, earthen pot, polyethylene bag (transparent) and gunny bag were used in this study. Freshly harvested seeds of cowpea were sun-dried for two days and five kg seeds were poured into each container on 10 August, 2011. All the containers were placed on a wooden rack at room temperature (25-30 ± 2^0C). The seeds kept in different containers were stored for a period of six months up to 10 February, 2012. The

polythene bag and gunny bag were tight with rope where as earthen pot and tin container was covered tightly. Samples of seeds were drawn from each container at monthly intervals. Data on moisture content, germination, vigor index and prevalence of fungi were recorded. Prevalence of different fungi was determined by blotter method following International rules for seed testing (Anonymous, 1996).

Moisture test: Moisture content (MC) was determined by using high constant temperature oven method following International rules for seed testing (Anonymous, 1999a). The moisture content of seeds (wet basis) was determined by using following formula. The procedure was performed after every 30 days from beginning of storage.

$$MC\ (\%) = \frac{M_1 - M_3}{M_2 - M_1} X100$$

Here, M_1 = weight of container + cover.

M_2 = weight of container + cover + seed before drying.

M_3 = weight of container + cover + seed after drying.

Germination test: Germination test (Anonymous, 1999b) was carried out to evaluate the germination percentage after storage. To reduce the microbial contamination during the test, seeds were surface sterilized with 0.1% Bavistin for two minutes and rinsed several times in sterile distilled water. Then the seed were dried in air on filter paper. The surface sterilized seeds were presoaked with distilled water for overnight and plated on petridishes, each containing 3 layers of blotters soaked with sterile distilled water. Twenty number of seeds/plate were sown and plates were incubated at room temperature for three days. Germination counts were recorded and percentage of germination was calculated using the following formula (Krishnasamy & Seshu, 1990).

$$Germination\ (\%) = \frac{\text{Number of seed germinated}}{\text{Total number of seeds used}} \times 100$$

Vigor index: Root and shoot length were recorded for each treatment to calculate the vigor index. Vigor index was calculated by using following formula (Mogle and Maske, 2012).

Vigor index (VI) = (mean root length + mean shoot length) x Germination (%)

100 seed weight: A composite seed sample from each treatment was taken and from each sample 100 seeds were counted and their weight was recorded.

Duncan's Multiple Range Test (DMRT) was followed for comparing treatment means at 0.05 level by using SPSS 16. Correlation co-efficient of germination and vigor index with moisture were separately determined in all the storage devices for different storage interval.

Results and Discussion

The seed moisture content, germination rate and vigor index of cowpea seeds varied with the variation of storage container at the end of the six months of storage (Table 1). Seed moisture content was maximal when the seeds were stored in gunny bag (18.2%), which was followed by earthen pitcher (15.1%), polythene bag (14.9%) and tin container (14.3%). On the other hand, the germination percentage was found highest when the seeds were stored in tin container (89.3%), which was followed by polythene bag (86.7%), earthen pitcher (76.7%) and gunny bag (50%). Similarly, vigor index was found highest when the seeds were stored in tin container (111.5), which was followed by polythene bag (99.0), earthen pitcher (97.4) and gunny bag (87.4). Effect of all the four storage containers on moisture content, seed germination and vigor index were significantly different from each other.

The effect of storage period on seed moisture, germination and vigor of cowpea seeds are also presented in the table 1. The initial moisture content of seeds was recorded after first month of storage in all the storage structures, which was almost similar both numerically as well as statistically. It was observed that, there was no variations in moisture content of seeds stored in tin container, which mean the moisture content of the seeds remain constant throughout the storage period. But the moisture content of the seeds stored in other devices exhibited lots of fluctuation. The fluctuation was observed in the seeds stored in gunny bag and also higher compared to seeds stored in other containers throughout the storage period. The percentage of seed germination recorded during the first month of storage in all devices was statistically similar. Significant reduction in germination was observed in the seeds stored in gunny bag throughout the storage period. But the seeds stored in other devices showed less reduction in germination compared to gunny bag. On the other hand, the seeds stored in tin container maintained proper germination rate throughout the storage period. A similar trend was also observed in case of vigor index as moisture content and germination rate.

Table 1: Effect of different storage containers on moisture content, germination and vigor index of cowpea seeds

Storage containers	Month of storage																	
	Moisture (%)						Germination (%)						Vigor index					
	1m	2m	3m	4m	5m	6m	1m	2m	3m	4m	5m	6m	1m	2m	3m	4m	5m	6m
TC	14.0^{a}	14.0^{a}	14.0^{a}	14.1^{b}	14.1^{c}	14.3^{c}	93.4^{a}	92.3^{a}	91.6^{a}	91.6^{a}	90.2^{a}	89.3^{a}	116.7^{a}	116.5^{a}	114.8^{a}	114.5^{a}	113.3^{a}	111.5^{a}
PB	14.1^{a}	14.7^{a}	14.7^{a}	14.8^{b}	14.9^{b}	14.9^{bc}	91.2^{a}	89.6^{ab}	88.6^{b}	87.4^{b}	87.3^{a}	86.7^{a}	117.5^{a}	115.3^{a}	112.8^{b}	107.2^{b}	102.5^{b}	99.0^{b}
EP	14.0^{a}	14.1^{a}	14.3^{a}	14.5^{b}	14.8^{b}	15.1^{b}	89.6^{a}	88.4^{b}	84.2^{c}	82.4^{c}	80.4^{b}	76.7^{b}	117.2^{a}	114.6^{a}	110.8^{c}	107.4^{b}	100.2^{c}	97.4^{b}
GB	14.1^{a}	14.3^{a}	15.0^{a}	16.3^{a}	17.1^{a}	18.2^{a}	90.2^{a}	88.4^{b}	81.6^{d}	78.4^{d}	62.6^{c}	50.0^{c}	116.9^{a}	105.5^{b}	98.6^{d}	95.2^{c}	88.4^{d}	87.4^{c}

TC: Tin container, EP: Earthen pitcher, PB: Polythene bag, GB: Gunny bag, m: month

The prevalence of fungi associated with cowpea seeds during storage varied among different types of container used (Table 1-4). Fungi associated with the cowpea seeds during storage period were *Alternaria alternata, Aspergillus niger, Aspergillus flavus, Aspergillus ochraceus, Aspergillus terrus, Aspergillus fumigatus, Cladosporium* sp., *Curvularia lunata, Chaetomium globosum, Fusarium solani, Nigrospora* sp., *Penicillium chrysogeum, Penicillium citrinum* and *Rhizopus* sp. The population of fungi was highest in the seeds stored in gunny bag, which was followed by earthen pitcher and polythene bag and the lowest incidence of these fungi were recorded in case of seeds stored in tin container throughout the storage period. The atmospheric relative humidity during the storage period was also recorded and it was found an average of approximately 70%.

Correlation coefficient of germination percentage and vigor index with moisture content was separately determined in all the storage devices for different storage interval to understand their relationship (Table 1-4). In tin container, germination correlated significantly with moisture at one, two and six months of storage and vigor index correlated with moisture at one, two, three and six months storage interval (Table 3). On the other hand, in polythene bag, only vigor index correlated with moisture at three and five

Table 2: Prevalence of fungi associated with cowpea seeds in different storage containers after one month of storage

Storage containers	Prevalence of fungi (%)													
	Aa	An	Af	Ao	At	Afu	C	Cl	Cg	Fs	N	Pch	Pc	R
TC	1.2^{b}	3.4^{d}	4.2^{d}	5.3^{c}	4.7^{c}	2.0^{d}	0.98^{d}	1.0^{b}	1.0^{c}	3.8^{d}	2.0^{d}	0.75^{d}	0.75^{c}	0.85^{c}
PB	1.4^{b}	5.2^{c}	5.8^{c}	5.4^{c}	5.0^{a}	2.6^{c}	1.2^{c}	1.0^{b}	1.2^{bc}	4.4^{c}	2.8^{c}	1.0^{c}	0.92^{bc}	0.95^{c}
EP	1.4^{b}	6.2^{b}	6.8^{b}	7.2^{b}	5.2^{b}	3.6^{b}	2.2^{b}	1.2^{a}	1.3^{b}	5.2^{b}	4.7^{b}	3.3^{b}	1.0^{b}	1.2^{b}
GB	1.8^{a}	6.8^{a}	8.9^{a}	9.2^{a}	8.3^{a}	6.4^{a}	2.9^{a}	1.2^{a}	4.8^{a}	6.6^{a}	6.3^{a}	5.8^{a}	2.6^{a}	3.1^{a}

Aa: *Alternaria alternata*, An: *Aspergillus niger*, Af: *Aspergillus flavus*, Ao: *Aspergillus ochraceus*, At: *Aspergillus terrus*, Afu: *Aspergillus fumigatus*, C: *Cladosporium* sp., Cl: *Curvularia lunata*, Cg: *Chaetomium globosum*, Fs: *Fusarium solani*, N: *Nigrospora* sp., Pch: *Penicillium chrysogeum*, Pc: *Penicillium citrinum*, R: *Rhizopus* sp.

Table 3: Prevalence of fungi associated with cowpea seeds in different storage containers after two months of storage

Storage containers	Prevalence of fungi (%)													
	Aa	An	Af	Ao	At	Afu	C	Cl	Cg	Fs	N	Pch	Pc	R
TC	1.4^{c}	5.2^{d}	5.1^{d}	6.6^{c}	6.2^{d}	2.4^{d}	1.0^{c}	1.2^{d}	1.4^{c}	5.2^{c}	2.8^{d}	1.0^{d}	0.75^{c}	0.90^{c}
PB	1.6^{c}	6.4^{c}	7.1^{c}	6.8^{c}	6.6^{c}	3.2^{c}	2.2^{b}	1.6^{c}	1.8^{c}	6.2^{b}	3.6^{c}	1.6^{c}	1.0^{c}	0.95^{c}
EP	2.8^{b}	8.6^{b}	10.6^{b}	11.8^{b}	6.8^{b}	5.4^{b}	3.2^{a}	2.0^{b}	5.8^{b}	6.5^{b}	5.8^{b}	5.2^{b}	1.8^{b}	1.4^{b}
GB	3.8^{a}	012.2^{a}	16.5^{a}	14.8^{a}	11.9^{a}	9.4^{a}	3.2^{a}	4.0^{a}	13.8^{a}	8.8^{a}	7.6^{a}	8.7^{a}	6.4^{a}	4.8^{a}

Table 4: Prevalence of fungi associated with cowpea seeds in different storage containers after three months of storage.

Storage containers	Prevalence of fungi (%)													
	Aa	An	Af	Ao	At	Afu	C	Cl	Cg	Fs	N	Pch	Pc	R
TC	1.8^{d}	6.7^{d}	7.8^{d}	7.0^{c}	7.0^{b}	3.2^{c}	1.2^{d}	1.4^{d}	2.0^{c}	8.2^{c}	3.8^{c}	1.4^{c}	0.95^{c}	1.0^{d}
PB	2.1^{c}	9.2^{c}	10.6^{c}	7.8^{c}	7.2^{b}	4.0^{c}	2.6^{c}	2.2^{c}	2.2^{c}	9.4^{c}	4.0^{c}	2.2^{c}	1.2^{bc}	1.6^{c}
EP	4.2^{b}	15.8^{b}	14.8^{b}	12.6^{b}	7.4^{b}	7.2^{b}	3.6^{b}	2.4^{b}	7.6^{b}	14.8^{b}	12.6^{b}	5.4^{b}	2.0^{b}	2.2^{b}
GB	7.2^{a}	30.8^{a}	34.6^{a}	32.8^{a}	21.6^{a}	16.6^{a}	4.6^{a}	4.2^{a}	20.2^{a}	22.4^{a}	18.7^{a}	12.8^{a}	11.2^{a}	5.8^{a}

Table 5: Prevalence of fungi associated with cowpea seeds in different storage containers after four months of storage.

Storage containers	Prevalence of fungi (%)													
	Aa	An	Af	Ao	At	Afu	C	Cl	Cg	Fs	N	Pch	Pc	R
TC	2.0^{d}	7.2^{d}	8.8^{d}	8.8^{c}	7.4^{b}	3.8^{c}	1.6^{d}	1.8^{c}	2.3^{c}	9.6^{c}	4.6^{c}	1.9^{c}	1.0^{c}	1.0^{d}
PB	2.6^{c}	10.8^{c}	11.6^{c}	8.8^{c}	7.8^{b}	4.6^{c}	3.0^{c}	2.8^{b}	2.7^{c}	10.6^{c}	4.8^{c}	2.8^{c}	1.2^{c}	2.0^{c}
EP	4.6^{b}	17.2^{b}	16.8^{b}	14.6^{b}	8.2^{b}	8.2^{b}	4.0^{b}	2.8^{b}	8.2^{b}	16.8^{b}	13.9^{b}	6.6^{b}	2.2^{b}	2.8^{b}
GB	7.6^{a}	33.2^{a}	37.6^{a}	34.8^{a}	23.6^{a}	18.7^{a}	5.2^{a}	4.6^{a}	21.9^{a}	23.7^{a}	20.8^{a}	14.4^{a}	12.8^{a}	6.2^{a}

Table 6: Prevalence of fungi associated with cowpea seeds in different storage containers after five months of storage.

Storage containers	Prevalence of fungi (%)													
	Aa	An	Af	Ao	At	Afu	C	Cl	Cg	Fs	N	Pch	Pc	R
TC	2.4^{c}	7.8^{c}	9.4^{c}	9.2^{c}	7.9^{b}	4.4^{c}	2.0^{d}	2.2^{c}	2.5^{c}	11.2^{d}	5.2^{c}	2.4^{c}	1.2^{c}	1.0^{c}
PB	3.0^{c}	11.2^{c}	12.1^{c}	9.2^{c}	8.0^{b}	5.0^{c}	3.1^{c}	3.0^{b}	3.0^{c}	13.8^{c}	5.2^{c}	3.1^{c}	1.4^{c}	2.2^{b}
EP	5.1^{b}	18.6^{b}	18.1^{b}	16.8^{b}	8.2^{b}	8.9^{b}	4.2^{b}	3.1^{b}	9.2^{b}	17.7^{b}	15.8^{b}	7.2^{b}	2.6^{b}	3.0^{b}
GB	8.0^{a}	34.8^{a}	40.2^{a}	37.6^{a}	25.4^{a}	20.2^{a}	5.9^{a}	5.2^{a}	24.8^{a}	25.7^{a}	23.6^{a}	16.6^{a}	13.9^{a}	7.2^{a}

Table 7: Prevalence of fungi associated with cowpea seeds in different storage containers after six months of storage.

Storage containers	Prevalence of fungi (%)													
	Aa	An	Af	Ao	At	Afu	C	Cl	Cg	Fs	N	Pch	Pc	R
TC	2.9^{c}	8.6^{c}	9.5^{d}	9.2^{c}	8.2^{b}	4.8^{c}	2.4^{c}	2.6^{c}	2.5^{c}	11.8^{c}	5.4^{c}	2.4^{c}	1.2^{c}	1.1^{c}
PB	3.2^{c}	11.4^{c}	12.6^{c}	09.8^{c}	8.4^{b}	5.6^{c}	3.4^{bc}	3.2^{bc}	3.4^{c}	14.2^{c}	5.6^{c}	3.8^{c}	1.7^{bc}	2.7^{b}
EP	5.8^{b}	19.4^{b}	18.5^{b}	17.6^{b}	8.8^{b}	9.8^{b}	4.6^{b}	3.8^{b}	9.4^{b}	18.6^{b}	16.4^{b}	7.4^{b}	2.6^{b}	3.4^{b}
GB	8.4^{a}	39.6^{a}	42.9^{a}	41.2^{a}	28.7^{a}	21.7^{a}	6.8^{a}	5.6^{a}	28.7^{a}	26.2^{a}	25.7^{a}	19.7^{a}	15.8^{a}	8.4^{a}

Table 8: Correlation coefficient of germination percentage and vigor index with moisture at different storage period stored in tin container

Source of variation	Storage period (month)											
	1		2		3		4		5		6	
	GE	VI	GE	VI	GE	VI	GE	VI	GE	VI	GE	VI
Moisture (%)	0.989**	0.992**	0.970**	0.992**	0.856	0.984**	0.856	0.984**	0.868	0.859	0.998**	0.873

** Correlation is significant at 0.01 level.
GE: Germination, VI: Vigor Index

Table 9: Correlation coefficient of germination percentage and vigor index with moisture at different storage period stored in polythene bag.

Source of variation	Storage period (month)											
	1		2		3		4		5		6	
	GE	VI	GE	VI	GE	VI	GE	VI	GE	VI	GE	VI
Moisture (%)	0.436	0.834	0.874	0.156	0.800	0.990**	0.756	0.422	0.763	0.987**	9.124	9.077

Table 10: Correlation coefficient of germination percentage and vigor index with moisture at different storage period stored in earthen pitcher.

Source of variation	Storage period (month)											
	1		2		3		4		5		6	
	GE	VI	GE	VI	GE	VI	GE	VI	GE	VI	GE	VI
Moisture (%)	0.847	0.800	0.800	0.990**	0.992**	0.103	0.868	0.763	0.095	0.965**	-0.567	-0.622

Table 11: Correlation coefficient of germination percentage and vigor index with moisture at different storage period stored in gunny bag.

Source of variation	Storage period (month)											
	1		2		3		4		5		6	
	GE	VI	GE	VI	GE	VI	GE	VI	GE	VI	GE	VI
VIMoisture (%)	0.998**	0.992**	0.984**	0.643	0.842	0.998**	0.996**	0.824	0.872	0.997**	0.999**	0.683

months of storage (Table 2). In earthen pitcher, germination correlated significantly with moisture at only three months of storage but vigor index correlated with moisture both at two and five months of storage (Table 3). Significant correlation was also observed between germination and moisture at one, two, four and six months of storage in gunny bag. Similarly, significant correlation was observed between vigor index and moisture at one, three and five months of storage interval (Table 4).

The germination rate of cowpea seeds varied widely due to different moisture content of the seeds stored in different storage devices. The present data reveal that the better germination performance of tin container followed by earthen pitcher and polythene bag might probably be less moisture content of the seed. A similar study was carried out by Alam *et al.,* (2009), where they reported that stored rice seeds having lower moisture content showed better germination**.** Malik and Shamet (2009) also observed better germination and vigor when the seeds were stored in tin container having lower moisture percentage in comparison to other storage devices. The result was in conformity with the finding of Paderes *et al.,* (1997), who found a significant negative correlation between germination percentage and moisture content. The decrease in seed germination with increasing moisture content and length of storage period has also been reported by many other workers (Christensen and Kaufmann, 1965; Gupta *et al.,* 1973; Rahman *et al.,* 1985; Cook and Veseth, 1991).

The moisture content of the seeds stored in different storage devices in the early period of storage was almost similar (around 14%) but it was increased with the increase in storage time. The increased rate was higher in the seeds stored in gunny bag. As seed is highly hygroscopic living material, it absorbs moisture from air if it is stored in an environment where relative humidity is higher than seed moisture content (Nahar *et al.,* 2009). The relative humidity was near 70% throughout the storage period. For this reason, seeds absorbed moisture from the ambient air and tended to equilibrium with relative humidity. The rate of absorbance was higher in gunny bag because of gunny bag is not air tight but tin container, polythene bag and earthen pitcher are almost moisture proof, so increasing rate was lower in these containers.

Reduction in germination and increase in moisture content of cowpea seeds during storage might be due to activity of the fungi. The assumption is supported by the fact that during later part of storage i.e. after six months, the prevalence of fungi, especially species of *Aspergillus*, *Penicillium* and *Nigrospora* increased in the seeds stored in gunny bag and germination decreased rapidly. This indicates that the fungi appeared during storage are also responsible for deterioration of cowpea seeds. Christensen and Kaufmann (1965) clearly demonstrated that increase in moisture content and fungi during the storage are responsible for decrease in germination.

Conclusion

The present study highlighted that gunny bag is not safe for long term storage of cowpea seed as the rate of moisture absorbance and fungal contamination were highest and performed fair percentage of germination compared to other storage devices. Among the devices, tin container exhibited better germination and vigor, and maintained lowest moisture content and fungal population. Therefore comparing all the storage structure, tin container has been proved as much safer and secure device for long term storage of cowpea seeds.

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