



## Research Article

# Effect of storage container and storage period on germination of grain maize in bako, West Shewa, Ethiopia

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## Abstract

Grain quality is in terms of heritably and physically pure whereas postharvest managements are used to increase grain/seed quality through seed processing while required storage condition maintain its quality. However, little information available on germination capacity of maize as affected by storage containers and period in Ethiopia. Thus, the aim of the study was to evaluate the effects of storage containers with storage period on germination of maize grain in the laboratory. The experiment was conducted between December 2017 and May 2018 in Bako, West Shawa, Ethiopia. The experiment was arranged in CRD designs with three replications. The treatments consist of two factors combinations with storage types (Gombisa, sack and Hermetic bag) and storage periods (0, 1, 2, 3, 4, 5, and 6) months. Germination test was done by the standard procedures of international seed test agency (ISTA). The collected data were analyzed statistically using Generalized Linear Model (GLM) procedure of SAS and means that were significantly different were separated using Least Significant Difference (LSD). The result showed significant different ( $P < 0.05$ ) interaction effect on germination. The values for initial loading were 98.0% and subsequently reduced 78.9% at the end of 6 months of storage. Initially, the highest 98.0% germination was recorded and reduced significantly ( $p < 0.05$ ) to 72.0, 76.0 and 88.6% for Gombisa, Sack and Hermetic bags, respectively. Hermetic bag kept significantly higher germination percentage with 94.2 % at six 6 months in storage, respectively as compared to the rest of the two storage containers. The reduction of germination of grain stored in Gombisa and Sack were due to the grain damaged by weevils (*S. zeamais*, *S. granaries*, *T. castaneum* and *S. cerealella*) and increment of moisture content due to insect infestation and mould growth. From this study, it can be concluded that maize grains which was stored for less than 4 months had shown better seed germination but variations were observed among the storage structures studied. Also, Hermetic bag storage showed better result with higher germination throughout the storage periods.

## Introduction

Maize is the second most widely cultivated crop in Ethiopia and is grown under diverse agro-ecologies and socioeconomic conditions typically under rain-fed production [1]. In 2013 about 6,674,048 tons of maize grain was produced in Ethiopia [2]. These productions of maize depend on various factors. Among these; seed quality and post-harvest management are the most important. Seed quality is in terms of genetically and physically pure whereas postharvest managements are used to increase seed quality through seed processing while required storage condition maintain its quality [2]. These factors influence on the success of seed germination, normal seedling and final seed production. Nielsen [3] defined germination as

the renewal of enzymatic activity that results in cell division and elongation and, ultimately, embryo emergence through the seed coat. However, germination in practical terms is the emergence of seedlings on the soil surface. Germination is triggered by absorption of water through the seed coat [3].

He also stated that the repeated wetting and drying cycles of seed maize in store can decrease seed viability and in severe cases stop germination altogether. Seed quality is judged by different end users such as farmers and industries. For instance, farmers expect to obtain high quality seeds that are able to germinate and produce normal seedlings under field conditions [4]. Seed quality of maize has the capacity to high germinate and might be contributed to high initial downward growth as



well fast growing subsequently good seedling establishment. Among the causes of seed insecurity in Africa is inadequate facilities and inappropriate methods for seed storage among rural farmers. This impairs the maintenance of sufficient and safe seed resources compounded with poverty, and insufficient technical and financial support [5]. Successful seed storage is the main to farmers' seed security and may also enable communities to generate income through collecting, storing and selling seeds. Seed storage problems are partly responsible for farmers' failure to save seeds of non-traditional crops [6].

Poor seed storage conditions have been reported to cause up to 10% loss in seed quality in the tropics mainly through loss of viability [7,8]. After eight months of maize storage in the uncontrolled warehouse in South Africa, the germination declined from 87–99% to 50–80% [9]. Therefore, the objective of this study was conducted observe the effectiveness of storage containers on germination which were evaluated every 30 days after starting the experiment. They found that seed stored in gombisa had low germination after 4, 5 and 6 months respectively. Longest storability was recorded in hermetic bag with all storage container used. They concluded that grain stored in hermetic bag were superior in storability compared to those stored in gombisa and sack in maintaining the germination level.

## Materials and methods

### Description of the study area

This study was conducted at Bako Agricultural Research Center located in East Wollega Zone of the Oromia Regional State, western Ethiopia at an altitude of 1650 meters above sea level (m.a.s.l). Bako lies at 9 °6" north latitude and 37° 9" east longitude in the sub-humid ecology of the country 260 km west of Addis Ababa and 8 km away to the South from the main road to Nekemte. Average annual rainfall at this location is 1237 mm. The rainy season extends from May to October and maximum rain is received in the months of July and August. Agro-ecologically, it has a warm humid climate with mean minimum, maximum and average air temperatures of 15, 30 and 23 °C respectively. The RH minimum, maximum and average of the area is (49, 74.7 and 61.85%), respectively. The major annual and perennial crops of the area include maize, sorghum, teff, noug, hot pepper, haricot bean, sweet potato, mango, banana, and sugar cane in order of importance. The study was conducted for six (6) moths starting from harvesting time in December, 2017 to May, 2018 at Bako National Maize Research Center.

### Experimental plan and design

The experiment was arranged in a 3x4 factorial combination with two factors, storage types and storage period in complete randomized design with three (3) replications. Storage types have three levels i.e. Gombisa, Sack and Hermetic bag while storage period have four levels that is (0, 1, 2, 3, 4, 5, and 6) months of storage periods. Data were collected at every two months interval, including at the start of the study making up four levels for the factor storage period.

## Experimental materials

The study materials were BH-661 maize of variety harvested in December, 2017 and three types of Gombisa and Sack and Hermetic bag storage structures.

### Sampling methods

A total of 90 samples of BH-661 maize variety were collected from each of storage structures periodically starting from the beginning of the storage (0, 1, 2, 3, 4, 5, and 6) months of storage periods. The samples were taken from the top, middle and bottom of the storage structures. The initial maize samples from each storage structures were taken as a control at the beginning of the storage. Each sample was taken by inserting the spear into the grain mass straight to the maximum depth from the top, middle and the bottom the storage.

### Data to be collected

**Temperature and relative humidity:** The temperature and relative humidity of the internal and external environment of the storage was measured at an interval of every week by using portable digital thermo-hygrometer (Hanna, HI8564) and measurement was done in the afternoon 3.00 p.m. in the day (to reduce variations) and at the time three data was taken and its average was recorded. Measurements were taken from the center, side, and top portion of the storage according to Befekadu, et al. [10].

**Grain damage:** The data of damage grains were obtained by the count and weighing method. Each five hundred (500g) grains were taken from initial to last storage periods and from each of the storage types and the number of damaged and un-damaged grain were obtained using a hand lens by searching for the presence of hole on the seeds. The percentage of damaged grains was calculated according to the methods used by Wambugu, et al. [11] as follows:

$$DG(\%) = \frac{\text{Munber of damaged grain}}{\text{Total number of grain samples}} \times 100$$

Where, DG = percentage of damaged grain

**Grain weight loss:** The per cent weight loss was calculated using initial and final grain weight measurements (180 days period). Weight Loss was obtained by using the formula (Adams and Schulton, 1978). Then, the percentage weight loss was calculated as follows:

$$\% \text{ Weight Loss} = \frac{(UND)-(DNU)}{U(ND)+NU} \times 100$$

Where, U- Weight of undamaged grains (g) NU- Number of undamaged grains (g) D- Weight of damaged grains (g) ND- Number of damaged grains (g)

**Moisture content:** Grain moisture content was determined by using the (AACC, 2005) standard procedures of oven dry methods. The grain was dried at a temperature of 105°C for three hours and after removed from the oven wait to cool in



a dissector and then weighed. Then, the moisture content was calculated as follows: -

$$MC (\%) = \frac{W_i - W_f}{W_f} \times 100$$

Where,  $W_i$  = weight initial  $W_f$  = weight final

**Germination test:** Germination test was carried out on the maize grain stored under Gombias, Sack and Hermetic bag. The sample was collected in every thirty (30) days intervals to assess how effective they were in maintaining the viability of the grain over the six months period (180 days). The baseline germination percentage was the initial loading sample taken. Seed germination test was done according to the standard procedures of ISTA (1994). Four hundred maize grains/sample were used. The grains were kept in petri-dish lined with filter paper moistened with about 4 ml distilled water in six replicates (50 grains/petri-dishes) and incubated at room temperature (av.25°C) for 5 to 7 days. The germinated grains were counted visually up on appearance of radicle and/or plumule and percentage germination was calculated as follows: -

$$\text{Germination (\%)} = \frac{\text{No. of germinated seeds}}{\text{Total No. of seeds planted in each petri-dish}} \times 100$$

## Statistical analysis

All the data collected were subjected to analysis of variance (ANOVA) by using the PROC GLM procedure (SAS institute, 2004) and difference among means were compared by the Least Significant Difference at 5% level of significance (Steel and Torie, 1980) [12]. The correlation parameters were examined using Pearson 's correlation coefficient using PROC CORR procedure of the SAS software (SAS Institute, 2004).

## Results and discussions

### Environmental data of the grain storages during the storage periods

The temperature data was presented in Table 1. The initial temperature during loading the storages was 22.25 °C. The temperature readings continued to increase continuously and reached 35.65, 34.15, 33.05 and 31.05 °C for Gombisa, Sack, Hermetic bag and the ambient, in the six months. Likewise, Befikadu, et al. (2014) reported the average temperature had ranged from 21.30 to 35 °C for Gombisa and 16.55 to 28.95 °C for Sack while Marek, et al. (2018) reported average values of temperature inside of the floored warehouse is 21.9 °C within the timeframe, with the maximum value of 32.6 °C and minimal value of 12.6 °C.

The rises in temperature within the storages could be the impact of the surrounding environment from which the heat is transferred into the storages (Table 2). At the same time the temperature in the storage can increase due to the respiration heat coming from living beings inside. The corresponding ambient temperature increased was more than that in the storage in the early months of the storage periods. However,

Suleiman (2015) reported that carbon dioxide, moisture, and heat produced through respiration of the grain causes an increase in temperature and dry matter loss of the stored grain.

### Effect of storage container and period on moisture content of the grain

The mean moisture content data of grains stored in the three types of storages for six months are given in Table 2. The initial moisture content was 10% for all storage types. The values did not change much after storage periods of one month. As time passed by the moisture contents in all three storage types decreased. For, instance the moisture content of samples in Gombisa dropped to 7.40% after two months, and that of Sack reduced to 8.40% and of the Hermetic bag to 7.80%. The reduction in moisture content of grains could be loss of moisture to the air in the storage through transpiration (Evaporation). In contrast, Niamketchi [13], reported that with an individual mean of 9.23 and 9.05% at the beginning (0 month), the moisture contents increased significantly ( $P < 0.001$ ) during the storage period. In the third months the moisture content of grains in Gombisa increased to 8.36% whereas those in Sack and Hermetic bag continued to drop to 8.00 and 7.50%, respectively. The reduction in moisture content of grains could be loss of moisture to the air in the storage through transpiration (Evaporation). The moisture content of the grains at and after the fourth months showed

**Table 1:** Mean of grain and ambient temperature of stored maize over storage periods.

Storage period (months)	Mean of temperature (°C)			Mean of ambient temperature (°C)
	Gombisa	Sack	Hermetic bag	
ILD	22.25 <sup>f</sup>	22.25 <sup>f</sup>	22.25 <sup>b</sup>	22.25 <sup>e</sup>
1	23.15 <sup>f</sup>	23.10 <sup>f</sup>	22.40 <sup>b</sup>	25.0 <sup>d</sup>
2	24.95 <sup>e</sup>	25.00 <sup>e</sup>	24.15 <sup>b</sup>	27.0 <sup>c</sup>
3	27.30 <sup>d</sup>	26.85 <sup>d</sup>	26.20 <sup>b</sup>	28.0 <sup>b</sup>
4	28.95 <sup>c</sup>	28.00 <sup>c</sup>	27.85 <sup>b</sup>	29.5 <sup>b</sup>
5	32.80 <sup>b</sup>	30.85 <sup>b</sup>	29.55 <sup>b</sup>	31.0 <sup>a</sup>
6	35.65 <sup>a</sup>	34.15 <sup>a</sup>	33.05 <sup>a</sup>	31.05 <sup>a</sup>
LSD (5%)	0.9	1	0.6	0.8
CV (%)	3.5	4.8	2.7	4.8

Note: Mean values ± standard deviation of three replicates within each column sharing similar letters were not significantly different by LSD test at  $P \leq 0.05$ , CV: coefficient of variation, LSD: least significant different, ILD: initial loading date.

**Table 2:** Effect of storage container and period on moisture content.

Storage Period (Months)	Mean of grain moisture content (% db)		
	Gombisa	Sack	Hermetic
ILD	10.00 ± 0.7 <sup>c</sup>	10.00 ± 0.52 <sup>c</sup>	10.0 ± 0.32 <sup>c</sup>
1	9.93 ± 0.71 <sup>c</sup>	10.00 ± 0.52 <sup>c</sup>	9.30 ± 0.13 <sup>c</sup>
2	7.40 ± 0.14 <sup>d</sup>	8.40 ± 0.21 <sup>d</sup>	7.80 ± 0.12 <sup>d</sup>
3	8.36 ± 0.23 <sup>d</sup>	8.00 ± 0.21 <sup>d</sup>	7.50 ± 0.11 <sup>d</sup>
4	10.50 ± 0.29 <sup>c</sup>	10.20 ± 0.26 <sup>c</sup>	9.86 ± 0.18 <sup>c</sup>
5	11.23 ± 0.29 <sup>b</sup>	10.46 ± 0.26 <sup>c</sup>	10.03 ± 0.22 <sup>c</sup>
6	13.9 ± 0.29 <sup>a</sup>	11.70 ± 0.20 <sup>b</sup>	10.70 ± 0.24 <sup>c</sup>
LSD (5%)	0.53	0.48	0.72
CV (%)	3.4	2.3	2.81

Note: Mean values ± standard deviation of three replicates within each column sharing similar letters were not significantly different by LSD test at  $P \leq 0.05$ , CV: coefficient of variation, LSD: least significant different, ILD: initial loading date.





continued increment reach 13.9, 11.7 and 10.70% at the end of six months storage periods for samples in Gombisa, Sack and Hermetic bag, respectively. These increments could be due to the moisture generated during respiration of the grain and other living things in the storages.

### Effect of storage container with storage period on grain damaged and weight loss

The main and interaction effects of the storage containers and periods on the germination percentage was given in Tables 3,4. From initially loading the first two months of storage periods no grain damaged were recorded and significantly ( $p < 0.05$ ) increased to 0.9, 2.7, 4.4 and 9.1% at 3<sup>rd</sup>, 4<sup>th</sup>, 5<sup>th</sup> and 6<sup>th</sup> months of storage. The values after the 3<sup>rd</sup>, 4<sup>th</sup>, 5<sup>th</sup> and 6<sup>th</sup> months were 1.10, 2.90, 5.30 and 12.3% for Gombisa, 1.00, 2.7, 4.1 and 9.3% for Sack, 0.6, 2.6, 3.7 and 5.7% for Hermetic bag, respectively. There were significantly different ( $p < 0.05$ ) high 12.3% followed by sack 9.3% and hermetic bag 5.7%, respectively. Likewise, Befikadu, et al. [10], reported 11.50 and 10.75% percentage of kernel damage for Gombisa and Sack

**Table 3:** Interaction effect of storage container with storage on damaged grain and germination.

Storage Period (Months)	Damaged Grain (%)			Germination (%)		
	Gombisa	Sack	Hermetic	Gombisa	Sack	Hermetic
ILD	-	-	-	98.0±0.00 <sup>a</sup>	98.0±0.00 <sup>a</sup>	98.0±0.00 <sup>a</sup>
1	-	-	-	98.0±0.00 <sup>a</sup>	98.0±0.00 <sup>a</sup>	98.0±0.00 <sup>a</sup>
2	-	-	-	96.0±2.00 <sup>b</sup>	96.0±1.15 <sup>b</sup>	98.0±2.00 <sup>a</sup>
3	1.10±0.00 <sup>a</sup>	1.00±0.00 <sup>a</sup>	0.6±0.00 <sup>b</sup>	90.0±2.00 <sup>d</sup>	93.3±1.15 <sup>c</sup>	96.0±2.00 <sup>b</sup>
4	2.9±0.58 <sup>f</sup>	2.7±0.62 <sup>f</sup>	2.6±0.00 <sup>f</sup>	86.6±2.00 <sup>f</sup>	88.7±3.06 <sup>e</sup>	94.0±2.00 <sup>c</sup>
5	5.3±0.58 <sup>c</sup>	4.1±0.47 <sup>d</sup>	3.7±0.44 <sup>e</sup>	76.7±2.00 <sup>h</sup>	84.0±3.06 <sup>d</sup>	90.7±2.31 <sup>d</sup>
6	12.3±0.58 <sup>a</sup>	9.3±0.47 <sup>b</sup>	5.7±0.44 <sup>e</sup>	72.0±2.00 <sup>i</sup>	76.0±2.00 <sup>h</sup>	88.6±2.31 <sup>e</sup>
LSD (5%)	0.39			1.6		
CV (%)	8.6			7		

Note: Mean values ± standard deviation of three replicates within each column sharing similar letters were not significantly different by LSD test at  $P \leq 0.05$ , CV: coefficient of variation, LSD: least significant different, ILD: initial loading date.

**Table 4:** Main effect of storage container with period on grain damage, germination and weight loss.

Storage periods (months)	Grain damaged (%)	Weight loss (%)	Germination (%)
ILD	-	-	98.0±2.02 <sup>a</sup>
2	-	-	96.7±2.37 <sup>b</sup>
3	0.90±0.00 <sup>d</sup>	1.20±0.00 <sup>d</sup>	93.1±2.45 <sup>c</sup>
4	2.7±1.08 <sup>c</sup>	3.1±1.06 <sup>c</sup>	89.8±2.32 <sup>d</sup>
5	4.4±1.30 <sup>b</sup>	5.3±1.30 <sup>b</sup>	83.8±2.20 <sup>e</sup>
6	9.1±1.72 <sup>a</sup>	9.7±1.51 <sup>a</sup>	78.9±1.79 <sup>f</sup>
LSD (5%)	0.55	0.51	1.6
Storage container			
Gombisa	3.6±1.35 <sup>a</sup>	4.4±1.00 <sup>a</sup>	86.6±1.35 <sup>c</sup>
Sack	3.3±1.15 <sup>b</sup>	2.8±0.16 <sup>b</sup>	89.3±1.94 <sup>b</sup>
Hermetic	2.1±0.67 <sup>c</sup>	1.96±0.08 <sup>c</sup>	94.2±1.79 <sup>a</sup>
LSD (5%)	0.39	0.36	1.1
CV (%)	20.2	16.6	1.9

Note: Mean values ± standard deviation of three replicates within each column sharing similar letters were not significantly different by LSD test at  $P \leq 0.05$ , CV: coefficient of variation, LSD: least significant different, ILD: initial loading date

respectively after 60 days of storage. Similarly, Waktole and Amsalu [14], reported that mean grain damage and weight losses caused by the pests under traditional storage practices were 64.50 and 58.85%, respectively.

Storage container also made significant ( $P < 0.05$ ) different in weight loss with records of 4.4, 2.8, and 1.96% for those stored in Gombisa, Sack and Hermetic bag, respectively. Likewise, Deepak and Prasanta [15], also estimated 0.2 to 11.8% weight loss due to insect infestation in maize after 6 months of storage in traditional granaries in Togo. However, Stephen [16], reported average weight loss of 3.2, 4.8, 6.8, 7.2 and 8.2% for PICS bag, barns, mud silo, polypropylene bag and jute sack, respectively. Similarly, Waktole and Amsalu [14], reported that mean percentage grain damage and weight losses caused by the pests under traditional storage practices were 64.50 and 58.85%, respectively.

### Effect of storage container with storage period on germination percentage

The effects of the storage containers on the germination percentage of maize grains stored for 180 days were presented in Table 3 & 4. There were significant different ( $P < 0.05$ ) among the storage containers throughout the storage periods. Also, there were highly significant differences ( $P \leq 0.01$ ) among the storage periods. The highest 98.0% germination percentage was recorded at the initial month of the storage period. For storage period, at 4, 5 and 6 months the values for germination percentage were 89.8, 83.8 and 78.9%, respectively. The highest value 94.2% of germination percentage was recorded in Hermetic bag followed by sack 89.3% and gombisa 86.6%, respectively. Highest 98.0% of germination percentage was recorded during the initial one month of storage.

At two months of storage the germination percentage started to reduce to 96.0% for gombisa and sack and in hermetic bag it was not significantly differences ( $P < 0.05$ ) showed reduction. The germination percentage values for grains stored in Gombisa were 98.0% in the initial and significantly dropped to 72.0% up to the 6<sup>th</sup> months. Similarly, for the Sack, the value was 98.0% and dropped to 76.0% and for Hermetic bag 98.0% and dropped to 88.6%, respectively. However, Kaleta and Górnicki [17-19], data revealed that the germination percentage decreased during the storage period, and decreased as the moisture content increased. With 18 % moisture content and above the germination percentage decreased to zero after 35 days of storage. Similarly, Befikadu, et al. [10] reported germination loss of grain stored in Gombisa and Sack increased might be due to destruction of seed by weevil (*Sitophilus* species) and Angoumois gran moth (*S. cerealella*).

## Conclusion

Maize grains which was stored for less than four to six months had shown better seed germination but variations were observed among the storage types studied. As grain stored for longer period, the tested maize grains were showed low germination, decreased germination rate was observed. Grain temperature, moisture content, weight loss and damaged grains showed an increasing pattern with prolonged storage.



Therefore, this directly influences the grains quality, which the farmers requirement quality of grains that permit to germinate and homogeneousness of the seedlings stands. Grains stored in hermetic bag storage container was ideal for maize grains to maintain maximum viability for higher germination percentage.

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