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Full Length Research Paper

Maize Hybrids Seed Germination Characters as affected by Seed Storage Periods, Conditions and Materials

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In order to investigate the effect of seed germination parameters during storage. A laboratory experiment designed to study the effects of storage periods, conditions. The objectives of this investigation were aimed to study the influence of storage periods of some maize hybrids under different conditions and materials on seed viability parameters. Three maize hybrids (Giza 176, Giza 168 and Giza 167) was storage at eight different storage periods (3, 6, 9, 12, 15, 18, 21 and 24 months) using three different packaging materials (plastic, cloth and paper bags) under two types of storage conditions (refrigerator at 4ºC ± 1 and incubator at 20ºC ± 1) conditions. The study was conducted at Giza Central Seed Testing Laboratory of Central Administration for Seed Certification (CASC), Ministry of Agriculture. Germination characters i.e. final germination percentage, germination rate, index of germination, germination energy and seedling vigor index were estimated. Results showed that the percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index decreased with increased of storage period. The highest averages of studied characters were obtained at the control treatment. After 3 months of storage to the end of storage period, Giza 176 hybrid surpassed other hybrids in all of the studied characters followed by Giza 167 hybrid, which came in the second rank. Stored hybrids were affected due to packaging materials but the effects were more pronounced in the plastic bags as compared to other bags. Storage under refrigerator conditions at 4ºC ± 1 exceeded storage under incubator condition in final germination percentage, germination rate, index of germination, germination energy and seedling vigor index. Results clearly showed that final germination percentage, germination rate, index of germination, germination energy and seedling vigor index insignificantly affected by varies interactions. In general, it could be summarized that for increasing germination characters of maize hybrid Giza 176, during storage, it should be storage under refrigerator conditions (4°C±1) seeds in cloth bags up to 12 months.

Keywords: Maize hybrids, Storage periods, Storage Materials and Storage conditions.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops in the world agricultural economy that is grown in more countries. It is widely used as a source of energy and protein in the human diet and animal feed. Maize as a crop has multiple uses but is chiefly grown for human and livestock consumption. The seeds and the cobs are used as basic raw material in various industries *i.e.* ethanol and hydrocarbon materials, production of corn oil, dextrose and high fructose corn sweetness. The seeds are processed and converted into needed preparations, flakes, grits and pops for human consumption (Kumar and Rai 2006). Generally, seed viability and vigor are maximum at the time of physiological maturity. After physiological maturity, seeds begin to deteriorate at varying rates depending on genetic factor and on the conditions of storage environment. Seed deterioration is defined as summation of all physical, physiological and biochemical changes occurring in a seed, which ultimately lead to its death.

Maize hybrids have an important role in maintenance of the viability during storage. Where maize hybrids differed significantly in germination percentage and other viability characters during storage In this connection(Ajayi et al., 2006), showed that the mean values of standard germination for 'Ulla' and 'Benicia' were significantly lower compared to the mean for 'Dea' A decline seed viability during the storage period was exhibited by results of the standard germination test (Govender et al., 2008). Seed germination decreased with the increase of storage period (Malaker et al., 2008). Significant differences between studied cultivars in viability curves. The results showed changes in seed vigor and germination of examined seeds (Strelec et al., 2010). Seed ageing d treatments affected the germination percentage and vigor index of the treated sets. Germination percentage and seedling vigour index were found to be maximum in the control set of CM-138, as compared with the CM-142 (Rai et al., 2011). The highest germination percentage, germination index, normal seedling percentage were achieved in control conditions. The results showed that increasing storage duration resulted higher reduction in germination characteristics. It also, showed that seeds of hybrid B maintained their germination, followed by the seeds of hybrid A and hybrid C(Tabatabaei and Naghibalghora 2013). Germination of the stored seeds decreased with increase time in storage. The seeds of (hybrid A) showed a decrease in germination only after 15 months of storage. For seeds of (hybrid C), a similar behavior was observed, with a decrease in seed germination after 12 and 9 months (Timóteo and Marcos-Filho 2013). There has been a linear reduction on physiological quality for hybrids P30F53H and DKB 240Y for both initial vigor levels. Hybrids P30F53H Medium and high vigor levels presented reductions of the percentage of normal seedlings for each day of seed storage (Dan et al., 2014). In hybrid DKB 240Y, vigor reduction was markedly observed. Germination and vigor of the studied maize seeds i.e. Oito carreiras, Cabo roxo and Lombo baio were significantly reduced during the storage periods (Stefanello et al., 2015). A significant difference on germination percentage, mean time to germination, germination index and emergence percentage within and among stored hybrids of maize seeds i.e. CML-395, CML-202, 142-1-e and A-7033. Seed stored longer duration resulted in delayed onset of germination, decreased the germination rate as well as germination index, slow seedling emergence and low weight of seedling traits. The germination curve of hybrid CML-395 showed very rapid increase until achieved maximum germination. Among the three-germination curve, low seed germination progress curve observed for parental line of 142-1-e (Belay et al., 2017).

Temperature and relative humidity are most important variable factors for storage, influenced seed conditions, which lead to the changes in seed quality. In addition, seed cultivars influenced and determined climate in the storage. The lowest germination was recorded from seeds stored in all the environments except in cold room. The second best germination was recorded from seeds stored at Rahangala where average environmental were 23.3/15.3°C (day/night) and 77% relative humidity (Mettananda et al., 2001). The differences between the two storage temperatures at –20°C and at ambient temperate room conditions were non-significant for standard germination test for stored seeds (Ajayi et al., 2006). Seeds when stored at RH levels below 28% retained germination above 70%, whereas storage above 60% RH resulted in less than 50 % germination (Daniel 2007). The temperature of storage had great effect on germination. Much better effect was found at the temperature of 20°C. The seeds of this sort germinate in a great percentage even at 30°C after 90 days of storage at 20°C (Bojovic 2010). Decrease in germination and vigor was much greater for seeds kept at 40°C than at 25°C. While, seeds kept at 4°C, did not show significant changes in either germination or vigor (Strelec et al., 2010). There was a significant effect of storage conditions on seedling vigor index. The results showed that the storage under refrigerator conditions at 10°C ± 1 exceeded storage under ambient conditions in seedling vigor index (Kandil et al., 2013). The highest germination percentage of storage seed was attained at 6% seed moisture contents at 5, 15 and 25°C but reduced at 35°C. Germination percentage of seeds with 6% moisture content stored at 5°C and 35°C was 72% and 44% respectively. While, germination percentage of seeds with 14% moisture content stored at 5°C and 35°C was 60% and 28% respectively (Tabatabaei 2013). The proper storage and optimum seed moisture content can affect the grain quality significantly. Seed germination, normal seedling percentage and germination index reduced with increase in seed moisture content and

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storage temperature, but mean time to germination increases by increase in seed moisture content and storage temperature (Tabatabaei and Naghibalghora 2013). It noticed that, under three environments: cold and dry chamber (10ºC and 30% RH), laboratory condition, and controlled condition (20°C and 70% RH), there were no-differences in the behavior of seed lots during storage, a greater reduction in seed germination being observed in controlled condition, where high relative humidity conditions contributed for the lower germination presented by the seeds (Timóteo and Marcos-Filho 2013). Storage of maize grain in cold conditions (10°C) caused a significant increase in kernel weight and seed germination comparing with storage in room conditions (25°C + 2) (Shabana et al., 2015). Storage at 10°C did not prevent the deterioration of maize seeds but was more effective at preserving the quality of the seed compared with storage at room temperature. A significant difference was observed between the two storage conditions (10°C and room temperature). Storage at 10°C showed the highest values of normal seedlings in relation to storage at room temperature, except for the results of the first germination test (Stefanello et al., 2015).

Packaging containers significantly affected viability and seedling vigor. Using package materials for storing maize hybrids seed is important to maintenance of high seed viability and vigor from the harvest to planting. In this respect (Mettananda et al., 2001), studied the effect of different packing materials i.e. poly-sacks, white polythene and clear polythene on seed viability. Results showed that lowest storability was recorded from seeds stored in poly-sacks whereas the highest storability was from seeds packed in clear polythene. Investigation the effect of storage containers i.e. dole, earthen pitcher, tin container, polyethylene bag and refrigerator (10°C) on soared seed. Among these types of storage container used, refrigerator appeared to be the best container to store seeds, which was followed by polyethylene bag and tin container. As a result, seed germination was higher in these three types of container as compared to dole and earthen pitcher (Malaker et al., 2008). Seeds stored in airtight bags maintaining viability and vigour so it had higher germination capacity, vigor and viability than those in gunny bags (Wambugu et al., 2009). Seed stored in aluminum and polyester bags showed high seed germination and seedling vigor index compared with plastic and clothes bags (Naguib et al., 2011). **S**eedling vigor index, of seed stored significantly affected by package materials i.e. jute bags and plastic bags. The results showed that a reduction in germination percentage and seedling vigor index was recorded after ageing treatments in both packages. While, seed stored in jute bags gives better performance in the comparison of seeds stored in plastic bags (Rai et al., 2011). Seedling vigor index significantly affected by storage package. Results indicated that cultivars stored in plastic bags were affected due to storage but the effects were more pronounced in the plastic bags as compared to cloth bags (Kandil et al., 2013). A significant difference due to germination and seedling vigor due to storage containers. The reduction in germination and seedling vigor was higher in jute bag in comparison to polythene bag (Verma and Verma 2014). The packing material influences on germination and vigor index. It showed that seeds stored in cloth bags recorded highest germination percentage and vigor index and seeds stored in poly bags recorded lower germination percentage and vigor index (Wani et al., 2014). The paper packaging material was favored for all grain quality parameters i.e. seed germination and grain moisture content when grains are stored in cold conditions, whereas it recorded the highest seed germination (100%) and moderate grain moisture content (8.33%) (Shabana et al., 2015). Storage using a paper bag at a temperature of 10°C did not prevent the deterioration of maize seeds but was more effective at preserving the quality of the seed compared with a plastic bag at room temperature. Storage in paper bag at 10°C showed the highest values of normal seedlings in relation to storage under plastic container, room temperature, except for results of the first germination test. The reduction in the number of normal seedlings was more pronounced in the accelerated aging test compared with the cold test[10]. Hermetic storage containers (Metal bin, Super grain bag, and Purdue Improved Crop Storage (PICS) bag) corroborated superiority over conventional storage containers (Fertilizer sack and earthen pot) and retaining quality in germination and vigor in stored maize seeds (Bhandari et al., 2017). Good storage is a basic requirement for seed production program as the maintenance of high seed viability and vigor from the harvest to planting to realize the important of the seed production program. For this reason, **s**tandard germination of maize seeds decreased through storage period increased when samples were drawn at monthly intervals for testing Standard Germination (Mettananda et al., 2001). A year later the samples were subjected to the standard germination test the decline in seed viability during the storage period was exhibited by results of the standard germination test (Govender et al., 2008). Seed germination decreased with the increase of storage period. The percentages of seed germination recorded during the first four months of storage were statistically similar, while a significant reduction in germination compared to The previous months and it continued up to of storage (Malaker et al., 2008), there were highly significant differences in vigour after 3 and 6 months storage. An analysis of seeds stored for 3 and 6 months revealed highly significant differences in both vigor and viability[18]. The low percentage of germination, noticed immediately after the harvest (without storage), and a considerably greater percentage registered 90 days after the harvest (Bojovic 2010). Storage period had a negative influence on seed germination rate (Mrđa et al., 2010).

Seed germination and vigor are significantly reduced during one-year storage only at elevated temperatures (Strelec et al., 2010). With increasing storage period from 0 to 18 months significantly the seed germination and seedling vigor index decreased, however, the poor vital seeds were recorded after 18 months from storage (Naguib et al., 2011). Germination percentage and seedling vigor index of stored seeds decreased with the period of ageing *i.e.* 4, 8 and 12 months (Rai et al., 2011). There was a significant effect of storage periods on seedling vigor index. The seedling vigor index was decreased as storage periods were increased (Kandil et al., 2013). The highest germination percentage, normal seedling percentage, germination index and the minimum mean time to germination were achieved under control conditions (0 day of storage). Therefore the minimum this traits were attained under 180 days of aging (Tabatabaei 2013). The highest germination percentage, germination index, normal seedling percentage were achieved in control conditions (0 day of storage) while, increasing storage duration resulted higher reduction in germination characteristics (Tabatabaei and Naghibalghora 2013). Germination of the stored corn seeds decreased with increase storage period (Timóteo and Marcos-Filho 2013). Throughout the storage period of maize seeds, there has been a linear reduction on physiological quality during 180 day storage (Dan et al., 2014). Decreasing in germination percentage and speed of germination with increase in storage periods (El-Abady 2014). Acceleration time aging had significant effect on germination mean time, the number of normal seedlings and seedling vigor index (Oskouei et al., 2014). After 6th months of storage germination and seedling vigour index was higher than storage at 8th month of storage (Verma and Verma 2014). The highest germination percentage and seedling vigor index obtained at the end of 3 months storage and it was decreased with increasing the storage periods up to 9 months (Wani et al., 2014). The physiological quality of these seed varieties decreased with the storage period[10] As seed stored longer duration resulted in delayed onset of germination, decreased the germination rate as well as germination index and slow seedling emergence (Belay et al., 2017).

Therefore, the objectives of the present study were aimed to study changes on germination characters of some maize hybrids stored for different periods under different storage condition in different storage materials and their interactions effect.

MATERIALS AND METHODS

The experiment was conducted at Giza Central Seed Testing Laboratory of Central Administration for Seed Certification, Ministry of Agriculture, Egypt, during 2016 and 2018. The objectives of this investigation were aimed to study response of three single yellow hybrid maize i.e. Giza 176, Giza 168 and Giza 167 obtained from Field Crops Research Institute, Agriculture Research Centre, Egypt. Storage for different periods i.e. 3, 6, 9, 12, 15, 18, 21 and 24 months under two storage conditions i.e. refrigerator conditions at 4 ± 1°C and incubator conditions at 20 ± 1°C storage in three different kind of packages materials i.e. seed storage in cloth bags, plastic bags and paper bags, on seed germination characters.

Treatments and Experimental Design

The treatments were arranged in Factorial experiment in Randomized Complete Block Design (RCBD), consisted of 648 treatments combinations resulted from three single yellow hybrid maize soared for eight storage periods, two storage conditions and three different kinds of package materials. Fifty seeds of each hybrid were allowed to germinate in four replicates in rolled rowels in the germination chamber at 25 ± 1 °C as per the procedure prescribed in International Seed Testing Association Rules (ISTA 2018).

Studied Characters

The stored maize hybrids seed subjected for determined of five germination characteristics, namely final germination percentage, germination rate, germination index, energy of germination and seedling vigor index were estimated as follows:

a. Final Germination Percentage (FGP %): The final germination percentage was calculated as percentage according to the following equation described by (Ellis and, Roberts 1981; Ruan et al., 2002).

$$FGP = \frac{\text{Number of normal germinated seeds}}{\text{Total number of seed tested}} \times 100$$

b. Germination Rate (day): Germination rate was calculated according to the following equation described by (Ellis and, Roberts 1981).

$$GR = \frac{\text{Number of normal germinated seeds}}{\text{Number of germination days}}$$

c. Germination Index (GI %): Germination index was calculated according to the following equation described by (Karim et al., 1992).

$$GI = \frac{\text{Germination \% in the each treatment}}{\text{Germination \% in the control}} \times 100$$

d.

e. Energy of Germination (EG %): Energy of germination was recorded at the fourth day as the percentage of germinated seeds four days after sowing relative to the number of seeds tested according to (Ruan et al., 2002).

$$EG = \frac{\text{Number of germinated seeds after the fourth day}}{\text{Number of seeds tested}} \times 100$$

f.

Table 1: Averages of final germination percentage (%), germination rate (day), germination index (%), energy of germination (%) and seedling vigor index (%) as affected by maize hybrids stored for different periods.

Hybrids (H)	Storage Periods (Month)									
	0	3	6	9	12	15	18	21	24	M
Final germination percentage (%)										
Giza 176	100.00	100.00	99.00	96.67	94.00	91.17	86.67	83.33	79.33	92.24
Giza 168	100.00	99.83	98.00	95.50	92.67	89.67	85.00	80.67	76.67	90.89
Giza 167	100.00	100.00	98.67	95.33	93.17	90.00	85.67	81.50	77.00	91.26
LSD 5%	NS	NS	NS	0.93	NS	1.27	NS	1.66	1.74	0.04
Germination rate (day)										
Giza 176	3.57	3.57	3.53	3.45	3.36	3.26	3.09	2.98	2.83	3.29
Giza 168	3.57	3.56	3.50	3.41	3.31	3.20	3.04	2.88	2.74	3.25
Giza 167	3.57	3.57	3.52	3.41	3.33	3.22	3.06	2.91	2.75	3.26
LSD 5%	NS	NS	NS	0.03	NS	NS	NS	0.06	0.06	0.01
Germination index (%)										
Giza 176	100.00	100.00	99.00	96.67	94.00	91.17	86.67	83.33	79.33	92.24
Giza 168	100.00	99.83	98.00	95.50	92.67	89.67	85.00	80.67	76.67	90.89
Giza 167	100.00	100.00	98.67	95.33	93.17	90.00	85.67	81.50	77.00	91.26
LSD 5%	NS	NS	NS	0.93	NS	1.27	NS	1.66	1.74	0.04
Energy of germination (%)										
Giza 176	97.00	94.00	91.17	86.67	83.33	79.33	74.33	71.00	68.50	82.81
Giza 168	95.00	92.67	89.67	85.00	80.67	76.67	72.00	67.67	65.17	80.50
Giza 167	96.00	93.00	90.00	85.67	81.50	77.00	72.67	68.50	65.17	81.06
LSD 5%	0.94	NS	1.27	NS	1.66	1.74	NS	2.65	2.88	0.61
Seedling vigor index (%)										
Giza 176	3560.00	3252.92	2958.57	2643.87	2366.18	2068.42	1748.23	1474.45	1168.17	2360.09
Giza 168	3470.00	3115.50	2792.43	2438.90	2124.38	1818.70	1529.05	1264.03	1013.53	2174.06
Giza 167	3522.50	3176.67	2865.75	2527.77	2264.55	1946.85	1651.93	1360.88	1074.18	2265.68
LSD 5%	12.00	22.79	40.88	33.70	33.95	35.92	37.12	33.31	29.53	10.32

g. Seedling Vigor Index (SVI %): Seedling vigor index was calculated according to the following equation described by (Abdel-Baki and Anderson 1973).
SVI = (Average shoot length + Average root length) X Germination %

Statistical Analysis:

All data of this study were statistically analyzed according to the technique of variance (ANOVA) for the Factorial Randomized Complete Block Design as published by (Gomez and Gomez 1991). Least significant of difference (LSD) method was used to test the differences between treatment means at 5 % levels of probability as described by (Snedecor and Cochran 1980). The data were analyzed statistically following RCBD design by MSTAT–C computer package that developed by (Russell 1986).

RESULTS AND DISCUSSION

Maize hybrids performance:

Concerning to the effect of studied maize hybrids the results in Table (1) clearly indicated that the means of averages of final germination percentage, germination rate, germination index, energy of germination and seedling vigor index was significantly affected due to the studied

maize hybrids. Results in Table (1) revealed that Giza 176 significantly exceeded the other studied hybrids in percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index. While, Giza 186 hybrids recorded the lowest percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index. The differences between genotypes might be due to the genetic factors and seed chemical composition influence the expression of seed deterioration and vigor decline. In this respect, there were significant variations among and within parental lines for germination and emergence percentage as well seedling traits in different storage period (Belay et al., 2017). Numerous accounts have suggested that some varieties of maize and other species store better than others under similar conditions (Wambugu et al., 2009). It could be noticed that Giza 176 hybrid surpassed Giza 167 hybrid and Giza 168 hybrid in percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index, by 1.06, 1.06, 1.06, 2.12 and 4.00 %, respectively, and by 1.47, 1.46, 1.47, 2.80 and 7.88 %, respectively.

Regarding to the results presented in Table (1) the percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index significantly affected maize hybrids stored for different periods. Results showed that Giza 176 hybrid surpassed other hybrids in percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index from pre storage to end of storage period followed by Giza 167 hybrid. While the lowest percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index was obtained from storage Giza 168 for 24 months. In this respect, mitotic index values could be reduced due to ageing in the root meristems of maize; which can also be attributed to mitotic inhibitions. Mitotic inhibition by ageing can be attributed to blocking of mitotic cycle, which may result from prolonged G2 period or to defective DNA synthesis. Cytological observations of dividing cells revealed an abundance of chromosomal irregularities, which were directly proportional to the durations of ageing treatment[6]. These results are in good accordance with those obtained (Ajayi et al., 2006; Govender et al., 2008; Malaker et al., 2008; Strelec et al., 2010; Rai et al., 2011; Tabatabaei and Naghibalghora 2013; Timóteo and Marcos-Filho 2013; Dan et al., 2014; Stefanello et al., 2015; Belay et al., 2017).

Storage conditions effects

Results in Table (2) reported that the storage conditions had significant effect on percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index. The results clearly indicated that storage maize seeds under refrigerator conditions at 4°C ± 1 surpassed storage maize seeds under incubator conditions at 20°C ± 1 in percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index by 2.36, 2.37, 2.36, 4.04 and 7.74 %, respectively. In The temperature increases the rate of metabolic and enzymatic reactions causing acceleration in the rate of deterioration. During the storage of maize seeds, a high temperature accelerates respiration, which directly affects the rate of chemical reactions as well as the activity of microorganisms. These microorganisms attack the seeds and in combination with metabolic processes, accelerate the deterioration of the seeds and can produce toxins that damage membranes and inhibit seed germination (Stefanello et al., 2015). Averages of percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index at different storage periods as affected by storage conditions shown in Table (2). The results clearly showed that the highest percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index was obtained from pre storage treatment without significant differences between them followed by storage under refrigerator condition at 4°C ± 1 for 3 months. The lowest percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index was obtained from storage under incubator conditions at 20°C ± 1 for 24 months. These results are in good agreement with those (Ajayi et al., 2006; Strelec et al., 2010; Timóteo and Marcos-Filho 2013; Stefanello et al., 2015; Mettananda et al., 2001; Bojovic 2010; Kandil et al., 2013; Tabatabaei 2013; Shabana et al., 2015).

Storage Package Materials Effects

Regarding to the effect of package materials the results in Table (3) clearly indicated that percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index was significantly affected due to the package materials. Results in Table (3) revealed that the highest percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index was obtained from storage maize seeds in cloth bags followed by paper bags. In the otherwise, storage maize seeds in plastic bags recorded the lowest percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index. It could be noticed that storage maize seeds in cloth bags surpassed storage maize seeds in paper bags and storage maize seeds in plastic bags in percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index, by 0.14, 0.17, 0.14, 0.50 and 2.32%, respectively, and by 0.71, 0.75, 0.71, 2.23 and 8.61%, respectively.

Table 2: Averages of final germination percentage (%), germination rate (day), germination index (%), energy of germination (%) and seedling vigor index (%) as affected by storage conditions.

Storage conditions (C)	Storage Periods (Month)									
	0	3	6	9	12	15	18	21	24	M
Final germination percentage (%)										
Refrigerator Conditions (4°C±1)	100.00	100.00	99.11	96.44	94.11	92.00	87.78	84.00	79.56	92.56
Incubator Conditions (20°C±1)	100.00	99.89	98.00	95.22	92.44	88.56	83.78	79.67	75.78	90.37
Sig.	NS	NS	*	*	*	*	*	*	*	*
H x C	NS	NS	NS	NS	NS	NS	NS	NS	NS	
Germination rate (day)										
Refrigerator Conditions (4°C±1)	3.57	3.57	3.54	3.45	3.36	3.29	3.13	3.00	2.84	3.31
Incubator Conditions (20°C±1)	3.57	3.57	3.50	3.40	3.30	3.16	2.99	2.84	2.70	3.23
Sig.	NS	NS	*	*	*	*	*	*	*	*
H x C	NS	NS	NS	NS	NS	NS	NS	NS	NS	
Germination index (%)										
Refrigerator Conditions (4°C±1)	100.00	100.00	99.11	96.44	94.11	92.00	87.78	84.00	79.56	92.56
Incubator Conditions (20°C±1)	100.00	99.89	98.00	95.22	92.44	88.56	83.78	79.67	75.78	90.37
Sig.	NS	NS	*	*	*	*	*	*	*	*
H x C	NS	NS	NS	NS	NS	NS	NS	NS	NS	
Energy of germination (%)										
Refrigerator Conditions (4°C±1)	96.00	94.11	92.00	87.78	84.00	79.56	75.00	71.22	68.56	83.14
Incubator Conditions (20°C±1)	96.00	92.33	88.56	83.78	79.67	75.78	71.00	66.89	64.00	79.78
Sig.	NS	*	*	*	*	*	*	*	*	*
H x C	NS	NS	NS	NS	NS	NS	NS	NS	NS	
Seedling vigor index (%)										
Refrigerator Conditions (4°C±1)	3517.50	3269.44	2976.38	2617.56	2346.31	2066.98	1751.23	1480.83	1193.94	2357.80
Incubator Conditions (20°C±1)	3517.50	3093.94	2768.12	2456.13	2157.10	1822.33	1534.91	1252.08	976.64	2175.42
Sig.	NS	*	*	*	*	*	*	*	*	*
H x C	NS	NS	NS	*	*	*	NS	NS	*	

The seed stored in jute bags enhances the storage life of maize seeds as compared to plastic bags. Seeds of inbred CM-138 showed better storability as compared with inbred CM-142[6]. The results in Table (3) clearly indicated that the percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index was obtained from pre storage treatments followed by storage maize seeds in cloth for 3 month without significant differences between them. In addition, the lowest percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index was obtained from storage maize hybrids in plastic bags for 24 months. These results are in good agreement with those reported by (Malaker et al., 2008; Stefanello et al., 2015; Mettananda et al., 2001; Kandil et al., 2013; Shabana et al., 2015; Wambugu et al., 2009; Naguib et al., 2011; Verma and Verma 2014; Wani et al., 2014; Bhandari et al., 2017).

Table 3: Averages of final germination percentage (%), germination rate (day), germination index (%), energy of germination (%) and seedling vigor index (%) as affected by storage package materials.

Package Materials (P)	Storage Periods (Month)									
	0	3	6	9	12	15	18	21	24	M
Final germination percentage (%)										
Paper Package	100.00	99.83	98.00	95.33	93.33	90.33	86.17	82.50	78.83	91.59
Plastic Package	100.00	100.00	98.67	95.83	93.17	90.00	85.17	80.67	76.17	91.07
Cloth Package	100.00	100.00	99.00	96.33	93.33	90.50	86.00	82.33	78.00	91.72
LSD 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.04
H × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	
C × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	
H × C × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	
Germination rate (day)										
Paper Package	3.57	3.56	3.50	3.41	3.34	3.23	3.08	2.95	2.82	3.27
Plastic Package	3.57	3.57	3.52	3.42	3.33	3.22	3.04	2.88	2.72	3.25
Cloth Package	3.57	3.57	3.54	3.44	3.34	3.23	3.07	2.94	2.79	3.28
LSD 5%	NS	NS	NS	NS	NS	NS	NS	NS	0.06	0.01
H × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	
C × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	
H × C × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	
Germination index (%)										
Paper Package	100.00	99.83	98.00	95.33	93.33	90.33	86.17	82.50	78.83	91.59
Plastic Package	100.00	100.00	98.67	95.83	93.17	90.00	85.17	80.67	76.17	91.07
Cloth Package	100.00	100.00	99.00	96.33	93.33	90.50	86.00	82.33	78.00	91.72
LSD 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.04
H × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	
C × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	
H × C × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	
Energy of germination (%)										
Paper Package	96.00	93.17	90.33	86.00	82.33	78.00	73.50	69.83	67.00	81.80
Plastic Package	96.00	93.17	90.00	85.17	80.67	76.17	71.33	66.83	64.00	80.37
Cloth Package	96.00	93.33	90.50	86.17	82.50	78.83	74.17	70.50	67.83	82.20
LSD 5%	NS	NS	NS	NS	NS	1.74	NS	2.65	2.88	0.61
H × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	
C × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	
H × C × P	NS	NS	NS	NS	NS	NS	NS	NS	NS	
Seedling vigor index (%)										

Table 3. Continue

Paper Package	**3517.50**	**3190.92**	**2917.80**	**2551.83**	**2296.07**	**1977.93**	**1678.32**	**1416.90**	**1132.40**	**2297.74**
Plastic Package	**3517.50**	**3110.42**	**2727.75**	**2403.38**	**2090.87**	**1792.65**	**1504.05**	**1233.68**	**967.20**	**2149.72**
Cloth Package	**3517.50**	**3243.75**	**2971.20**	**2655.32**	**2368.18**	**2063.38**	**1746.85**	**1448.78**	**1156.28**	**2352.36**
LSD 5%	**NS**	**22.79**	**40.88**	**33.70**	**33.95**	**35.92**	**37.12**	**33.31**	**29.53**	**10.32**
H × P	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	
C × P	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	
H × C × P	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	

Table 4: Averages of final germination percentage (%), germination rate (day), germination index (%), energy of germination (%) and seedling vigor index (%) as affected by storage periods.

Storage Periods (month)	Final germination percentage (%)	Germination rate (day)	Germination index (%)	Energy of germination (%)	Seedling vigor index (%)
0 (Pre storage)	**100.00**	**3.570**	**100.00**	**96.00**	**3517.50**
3 months	**99.94**	**3.568**	**99.94**	**93.22**	**3181.69**
6 months	**98.56**	**3.519**	**98.56**	**90.28**	**2872.25**
9 months	**95.83**	**3.424**	**95.83**	**85.78**	**2536.84**
12 months	**93.28**	**3.334**	**93.28**	**81.83**	**2251.71**
15 months	**90.28**	**3.226**	**90.28**	**77.67**	**1944.66**
18 months	**85.78**	**3.063**	**85.78**	**73.00**	**1643.07**
21 months	**81.83**	**2.922**	**81.83**	**69.06**	**1366.46**
24 months	**77.67**	**2.773**	**77.67**	**66.28**	**1085.29**
LSD 5%	**0.69**	**0.02**	**0.69**	**1.06**	**17.88**

Storage Periods Effects

The results showed a significant effect of storage periods on the means of percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index (Table 4). The results showed that percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index were decreased as storage periods were increased. Results clearly indicated that before storage treatments significantly exceeded the other storage periods in percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index followed by after 3 months. While, after 24 months from storage recorded lowest percentage of final germination, germination rate, germination index, energy of germination and seedling vigor index. Seed stored for longer period would impact on chromosomal aberration, DNA can be damaged and or protein degradation thus causes the seed deterioration might be resulted in loss seed germination potential and seedling establishment. The differences in final germination percentages and other seedling characters due to storage periods might be due to chromosomal damages which causes of reduced germination and other seedling characters as compared to control (Rai et al., 2011). These results are in good agreement with those reported by (Govender et al., 2008; Malaker et al., 2008; Strelec et al., 2010; Timóteo and Marcos-Filho 2013; Dan et al., 2014; Stefanello et al., 2015; Belay et al., 2017; Bojovic 2010; Kandil et al., 2013; Tabatabaei 2013; Wambugu et al., 2009; Naguib et al., 2011; Verma and Verma 2014; Wani et al., 2014; Mrđa et al., 2010; El-Abady 2014; Oskouei et al., 2014).

CONCLUSION

Accordingly, it could be summarized that for increasing germination characters of maize hybrid Giza 176, during storage, it should be storage under refrigerator conditions (4°C±1) seeds in cloth bags up to 12 months.

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