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Full Length Research Paper

Seedling Parameters of Some Maize Hybrids as affected by Seed Storage Periods, Conditions and Materials

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In order to investigate influenced seedling parameters of some maize hybrids i.e. Giza 176, Giza 168 and Giza 167 during aging in different packaging materials i.e. plastic, cloth and prepare bags under two storage conditions i.e. refrigerator at 4°C ± 1 and incubator condition at 20°C ± 1 at eight different storage periods of 3, 6, 9, 12, 15, 18, 21 and 24 months. The studied seedling parameters were shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight were estimated. The results revealed that shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight decreased with increased of storage period. The highest averages of studied characters were obtained at the control treatment. Maize hybrids stored in plastic bags were affected due to storage but the effects were more pronounced in the plastic bags as compared to cloth bags. It could be stated that Giza 176 hybrid exceeded the other cultivars in shoot length, root length, seedling fresh weight and seedling dry weight. Storage under refrigerator conditions at 4°C ± 1 exceeded storage under incubator condition in all studied seedling parameters. Results clearly showed that shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight significantly affected by the varies interactions.

Keywords: Maize hybrids, packaging materials, storage conditions and periods, seedling parameters

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 (Rai et al., 2011), observed that ageing treatments affected the seedling characters i.e. root length, shoot length, seedling length, seedling dry weight, and vigour index I and II of the treated sets. Germination percentage and seedling characters were found to be maximum in the control set of CM-138, as compared with the CM-142. Root and shoot length, seedling fresh and dry weight and seedling vigor index significantly affected by studFied cultivars. Results showed that Giza 111 exceeded the other cultivars in root length, shoot length and seedling vigor index. Giza 22 and Giza 21 cultivars exceeded the other cultivars in root/ shoot ratio. Giza 35 exceeded other cultivars in seedling dry and fresh weight (Kandil et al., 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. In hybrid DKB 240Y, vigor reduction was markedly observed (Dan et al., 2014). There was significant difference on, fresh weight of shoot and root within and among stored hybrids of maize seeds i.e. CML-395, CML-202, 142-1-e and A-7033. The result showed that as seed stored longer duration resulted in low weight of seedling traits (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 hybrids influenced and determined climate in the storage. Decrease in vigour was much greater for seeds kept at 40 °C than at 25 °C. On the other hand, seeds kept at 4 °C, did not show significant changes in vigour (Strelec et al., 2010). There was a significant effect of storage conditions on the average of root length, shoot length, seedling fresh weight and seedling vigor index. The results showed that the storage under refrigerator conditions at 10 °C ± 1 exceeded storage under ambient conditions in root length, shoot length and seedling fresh and dry weight and seedling vigor index (Kandil et al., 2013). Storage of maize grain in cold conditions (10 ^{o}C) caused a significant increase in kernel weight comparing with storage in room conditions (25 + 2 ^{o}C) (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) (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 vigour 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. The effect of storage containers i.e., dole, earthen pitcher, tin container, polyethylene bag and refrigerator (10^{o}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 (Malaker et al., 2008). Seeds stored in airtight bags maintaining viability and vigour so it had higher vigour and viability than those in gunny bags (Wambugu et al., 2009). Seed stored in aluminum and polyester bags showed high seedling length and seedling dry weight compared with plastic and clothes bags (Naguib et al., 2011). **A** reduction in germination percentage, root length, shoot length, seedling length, seedling dry weight, vigour index was recorded after ageing treatments in both packages (Rai et al., 2011). While, seed stored in jute bags gives better performance in the comparison of seeds stored in plastic bags. Root and shoot length, seedling fresh and dry weight and 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 vigour due to storage containers. The reduction in seedling parameters was higher in jute bag in comparison to polythene bag (Verma and Verma 2014). The paper packaging material was favored for all grain quality parameters i.e., kernel weight when grains are stored in cold conditions, whereas it recorded the highest kernel weight (34.86g) (Shabana et al., 2015).

Good storage is a basic requirement for seed production program as the maintenance of high seed viability and vigour from the harvest to planting to realize the important of the seed production program. For this reason (Wambugu et al., 2009), showed that 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 vigour and viability. Seed vigour is significantly reduced during one-year storage only at elevated temperatures (Strelec et al., 2010). With increasing storage period from 0 to 18 months seedling length, growth rate, seedling and dry weight decreased however, the poor vital seeds were recorded after 18 months from storage (Naguib et al., 2011). Root length, shoot length, seedling length, seedling and dry weight 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 the means of root length, shoot length, seedling dry weight, and seedling fresh weight. The results showed that root length, shoot length, seedling fresh and dry weight were decreased as storage periods were increased (Kandil et al., 2013). **D**ecreasing in shoot length, root length and seedlings dry weight with increase in storage periods (El-Abady

2014). Acceleration time aging had significant effect on seedling weight and seedling length (Oskouei et al., 2014). "JM-216". The data shows that the highest quality parameters 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). As seed stored longer duration resulted in slow seedling emergence and low weight of seedling traits (Belay et al., 2017).

Therefore, the present study was aimed to study changes on seedling parameters 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 objective of this investigation was 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 and 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 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 Rules 2018).

Studied Characters

The stored maize hybrids seed subjected for determined of six seedling parameters namely, shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight were estimated as follows:

a. Shoot Length (cm): Average of the shoot length of the five seedlings from the seed to the tip of the leaf blade were recorded and expressed in centimeters as the shoot length.

b. Root Length (cm): Average of the root length of five seedlings from the seed to the tip of the root were recorded and expressed in centimeters (cm) as the root length.

c. Shoot Fresh Weight (mg): Average the weight of five seedling shoots were measured and expressed in milligram (mg) as the shoot fresh weight.

d. Root Fresh Weight (mg): Average the weight of five seedling roots were measure and expressed in milligram (mg) as the root fresh weight.

e. Shoot Dry Weight (mg): Average the weight of five seedling shoots were recorded and expressed in milligram (mg) after oven drying at 75 ºC for 48 h.

g. Root Dry Weight (mg): Average the weight of five seedling roots were recorded and expressed in milligram (mg) after oven drying at 75 ºC for 48 h.

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 shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight was significantly affected due to the studied maize hybrids. Results in Table (1) revealed that Giza 176 significantly exceeded the other studied hybrids in shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight. While, Giza 186 hybrids recorded the lowest values of shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight. 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 (Belay et al., 2017), reported that there were significant variations among and within parental lines for germination and emergence percentage as well seedling traits in different storage period. Numerous accounts have suggested that some varieties of maize and other species store better than others under similar conditions (Wambugu et al., 2009). This is an irreversible process and

Table 1: Averages of shoot length (cm), root length (cm), shoot fresh weight (mg), root fresh weight (mg), shoot dry weight (mg) and root dry weight (mg) as affected by maize hybrids stored for different periods.

Hybrids (H)	Storage Periods (Month)								
	0	3	6	9	12	15	18	21	24	M
Shoot length (cm)										
Giza 176	19.65	18.00	16.50	15.09	13.90	12.50	11.11	9.73	8.09	13.84
Giza 168	19.20	17.28	15.77	14.08	12.65	11.17	9.91	8.62	7.29	12.89
Giza 167	19.50	17.57	16.08	14.63	13.40	11.92	10.64	9.20	7.70	13.40
LSD 5%	0.06	0.11	0.12	0.12	0.13	0.13	0.13	0.14	0.10	0.04
Root length (cm)										
Giza 176	15.95	14.52	13.38	12.25	11.28	10.17	9.04	7.93	6.61	11.24
Giza 168	15.50	13.92	12.72	11.45	10.25	9.08	8.05	7.02	5.89	10.43
Giza 167	15.73	14.20	12.97	11.89	10.90	9.69	8.63	7.45	6.20	10.85
LSD 5%	0.08	0.10	0.11	0.10	0.11	0.11	0.12	0.11	0.10	0.03
Shoot fresh weight (mg)										
Giza 176	550.13	480.11	458.86	426.48	396.38	363.58	329.04	293.01	248.93	394.06
Giza 168	527.55	436.02	423.43	385.97	347.81	313.45	285.21	252.15	221.37	354.77
Giza 167	540.08	478.73	435.75	397.98	358.67	327.48	293.14	263.03	226.57	369.05
LSD 5%	2.04	3.13	3.79	3.88	3.83	3.70	3.79	3.27	3.30	1.11
Root fresh weight (mg)										
Giza 176	215.85	188.55	177.57	163.91	149.53	135.22	120.02	105.52	86.15	149.14
Giza 168	211.00	172.24	169.27	152.23	137.01	121.07	107.56	94.00	79.41	138.20
Giza 167	213.05	187.16	172.24	157.80	144.70	129.11	114.61	99.37	84.30	144.71
LSD 5%	0.86	1.29	1.49	1.52	1.51	1.46	1.54	1.45	1.13	0.44
Shoot dry weight (mg)										
Giza 176	42.55	37.68	36.01	33.47	30.66	28.53	25.82	23.00	19.54	30.81
Giza 168	41.45	34.31	33.35	30.28	27.23	24.61	22.37	19.80	17.37	27.86
Giza 167	41.95	36.32	34.31	31.22	28.15	25.68	23.07	20.65	17.96	28.81
LSD 5%	0.20	0.29	0.31	0.31	0.35	0.29	0.29	0.26	0.31	0.09
Root dry weight (mg)										
Giza 176	20.38	17.71	16.81	15.35	14.08	12.72	11.23	9.93	8.03	14.03
Giza 168	19.65	16.07	15.81	14.23	13.10	11.55	10.29	8.87	7.53	13.01
Giza 167	19.93	16.20	16.07	14.78	13.50	12.05	10.83	9.31	7.93	13.40
LSD 5%	0.13	0.13	0.15	0.19	0.14	0.13	0.15	0.13	0.12	0.04

consequence of the genetic constitution of the seed, the environment during its development and its chemical composition (Stefanello et al., 2015). It could be noticed that Giza 176 hybrid surpassed Giza 167 hybrid and Giza 168 hybrid in shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight, by 3.15, 3.44, 6.35, 2.98, 6.48 and 4.47 %, respectively, and by 6.90, 7.16, 9.97, 7.34, 9.56 and 7.23 %, respectively. Regarding to the results presented in Table (1) the shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight significantly affected maize hybrids stored for different periods. Results showed that Giza 176 hybrid surpassed other hybrids in shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight from pre-storage to end of storage period followed by Giza 167 hybrid. While the lowest means of shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight was obtained from storage Giza 168 for 24 months. In this respect (Rai et al., 2011), reported that 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. These results are in good accordance with those obtained by (Rai et al., 2011; Kandil et al., 2013; Dan et al., 2014; Belay et al., 2017).

Storage conditions effects

Results in Table (2) reported that the storage conditions had significant effect on averages length of shoots and roots, fresh weight of shoots and roots and dry weight of shoots and roots. The results clearly indicated that storage under refrigerator conditions at 4°C ± 1 surpassed storage under incubator conditions at 20°C ± 1 in shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight by 6.71, 5.67, 8.13, 6.32, 8.35 and 5.19 %, respectively. In this respect (Stefanello et al., 2015), reported 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. These results are in good harmony with those obtained by (Kandil et al., 2013; Strelec et al., 2010; Shabana et al., 2015; Stefanello et al., 2015). Averages of shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight at different storage periods as affected by storage conditions shown in Table (2). The results clearly showed that the highest averages of shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight 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 values of averages of shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight was obtained from storage under incubator conditions at 20°C ± 1 for 24 months. These results are in good agreement with those (Kandil et al., 2013; Strelec et al., 2010; Stefanello et al., 2015).

Storage Package Materials Effects

Regarding to the effect of package materials the results in Table (3) clearly indicated that averages length of shoots and roots, fresh weight of shoots and roots and dry weight of shoots and roots was significantly affected due to the package materials. Results in Table (3) revealed that the highest shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight was obtained from storage maize seeds in cloth bags followed by paper bags. While, stored maize seeds in plastic bags recorded the lowest values of shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight. In this respect (Rai et al., 2011), suggest that 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.

The results in Table (3) clearly indicated that the highest shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight was obtained from pre-storage treatments without significant differences between them followed by storage maize seeds in cloth for 3 months. In addition, the lowest shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight was obtained from storage maize hybrids in plastic bags for 24 months. These results are in good agreement with those reported by (Rai et al., 2011; Kandil et al., 2013; Shabana et al., 2015; Mettananda et al., 2001; Wambugu et al., 2009; Verma and Verma 2014).

Storage Periods Effects

The results showed a significant effect of storage periods on the means of shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight (Table 4). The results showed that shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight were decreased as storage periods were increased. Results clearly indicated that before storage treatments significantly exceeded the other storage periods in shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight followed by after 3 months. While, after 24 months from storage recorded lowest shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight. In this regard, the decline in shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight with increase of storage periods might be due to their genetic differences age induced deterioration, inherent differences in seed structure and composition (Manomani 2002).

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 (Whittle 2006). It could be concluded that increasing storage periods from 3, 6, 9, 12, 15, 18, 21 and 24 months decreased shoot length by 9.42, 17.15, 24.95, 31.53, 39.02, 45.76, 52.77 and 60.45 %, respectively compared with shoot length before storage. Increasing storage periods from 3, 6, 9, 12, 15, 18, 21 and 24 months decreased root length by 9.60, 17.19, 24.55, 31.27, 38.65, 45.48, 52.53 and 60.35 %, respectively compared with root length before storage. Increasing

Table 2: Averages of shoot length (cm), root length (cm), shoot fresh weight (mg), root fresh weight (mg), shoot dry weight (mg) and root dry weight (mg) as affected by storage conditions.

Storage conditions (C)	Storage Periods (Month)								
	0	3	6	9	12	15	18	21	24	M
Shoot length (cm)										
Refrigerator Conditions (4°C±1)	19.45	18.18	16.67	15.01	13.81	12.41	11.02	9.73	8.29	13.84
Incubator Conditions (20°C±1)	19.45	17.05	15.56	14.19	12.83	11.32	10.08	8.64	7.09	12.91
Sig.	NS	*	*	*	*	*	*	*	*	*
H x C	NS	NS	NS	NS	NS	NS	NS	NS	NS	
Root length (cm)										
Refrigerator Conditions (4°C±1)	15.73	14.51	13.36	12.13	11.13	10.05	8.92	7.88	6.69	11.16
Incubator Conditions (20°C±1)	15.73	13.92	12.68	11.60	10.49	9.24	8.23	7.05	5.78	10.52
Sig.	NS	*	*	*	*	*	*	*	*	*
H x C	NS	NS	NS	NS	NS	NS	NS	NS	NS	
Shoot fresh weight (mg)										
Refrigerator Conditions (4°C±1)	539.25	479.83	455.85	420.94	385.46	355.14	319.62	288.35	251.32	388.42
Incubator Conditions (20°C±1)	539.25	450.08	422.85	386.01	349.79	314.52	285.31	250.44	213.26	356.83
Sig.	NS	*	*	*	*	*	*	*	*	*
H x C	NS	NS	NS	NS	NS	NS	NS	NS	NS	
Root fresh weight (mg)										
Refrigerator Conditions (4°C±1)	213.30	187.38	178.06	162.04	148.65	134.43	119.29	105.68	89.66	148.72
Incubator Conditions (20°C±1)	213.30	177.92	168.00	153.92	138.85	122.50	108.84	93.58	76.91	139.31
Sig.	NS	*	*	*	*	*	*	*	*	*
H x C	NS	NS	NS	NS	NS	NS	NS	NS	NS	
Shoot dry weight (mg)										
Refrigerator Conditions (4°C±1)	41.98	37.30	35.92	33.02	30.23	27.85	25.09	22.63	19.86	30.43
Incubator Conditions (20°C±1)	41.98	34.90	33.19	30.29	27.13	24.70	22.42	19.66	16.73	27.89
Sig.	NS	*	*	*	*	*	*	*	*	*
H x C	NS	NS	NS	NS	NS	NS	NS	NS	NS	
Root dry weight (mg)										
Refrigerator Conditions (4°C±1)	19.98	17.14	16.58	15.05	13.88	12.54	11.15	9.86	8.35	13.84
Incubator Conditions (20°C±1)	19.98	16.18	15.88	14.52	13.25	11.68	10.42	8.88	7.30	13.12
Sig.	NS	*	*	*	*	*	*	*	*	*
H x C	NS	NS	NS	NS	NS	NS	NS	NS	NS	

Table 3: Averages of shoot length (cm), root length (cm), shoot fresh weight (mg), root fresh weight (mg), shoot dry weight (mg) and root dry weight (mg) as affected by storage package materials.

Package Materials (P)	Storage Periods (Month)									
	0	3	6	9	12	15	18	21	24	M
Shoot length (cm)										
Paper Package	19.45	17.70	16.44	14.75	13.57	12.05	10.71	9.44	7.88	13.56
Plastic Package	19.45	17.19	15.25	13.82	12.40	10.96	9.72	8.40	7.00	12.69
Cloth Package	19.45	17.96	16.65	15.22	13.99	12.58	11.23	9.73	8.20	13.89
LSD 5%	NS	0.11	0.12	0.12	0.13	0.13	0.13	0.14	0.10	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	
Root length (cm)										
Paper Package	15.73	14.25	13.33	12.00	11.02	9.80	8.73	7.68	6.43	11.00
Plastic Package	15.73	13.91	12.39	11.25	10.02	8.93	7.92	6.87	5.69	10.30
Cloth Package	15.73	14.48	13.35	12.34	11.39	10.21	9.08	7.85	6.59	11.22
LSD 5%	NS	0.10	0.11	0.10	0.11	0.11	0.12	0.11	0.10	0.03
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	
Shoot fresh weight (mg)										
Paper Package	539.25	474.14	452.55	410.75	372.53	336.57	302.28	269.75	237.77	377.29
Plastic Package	539.25	435.84	403.21	370.42	332.79	301.75	270.56	240.73	204.31	344.32
Cloth Package	539.25	484.88	462.28	429.26	397.54	366.18	334.55	297.72	254.79	396.27
LSD 5%	NS	3.13	3.79	3.88	3.83	3.70	3.79	3.27	3.30	1.11
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	
Root fresh weight (mg)										
Paper Package	213.30	186.45	179.45	162.02	148.58	132.58	117.19	103.99	86.29	147.76
Plastic Package	213.30	171.34	158.41	144.71	129.09	114.68	101.48	88.09	73.25	132.70
Cloth Package	213.30	190.15	181.22	167.21	153.58	138.15	123.53	106.81	90.32	151.59
LSD 5%	NS	1.29	1.49	1.52	1.51	1.46	1.54	1.45	1.13	0.44
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	
Shoot dry weight (mg)										
Paper Package	41.98	36.88	35.63	32.24	28.77	26.44	23.79	21.17	18.77	29.52
Plastic Package	41.98	33.80	31.65	29.06	26.10	23.68	21.25	18.91	16.04	26.94
Cloth Package	41.98	37.63	36.39	33.67	31.17	28.71	26.22	23.37	20.06	31.02
LSD 5%	NS	0.29	0.31	0.31	0.35	0.29	0.29	0.26	0.31	0.09
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 3: Continue

Root dry weight (mg)										
Paper Package	19.98	17.01	16.71	15.08	13.86	12.35	10.93	9.67	7.93	13.73
Plastic Package	19.98	15.57	15.11	13.79	12.50	11.07	9.90	8.43	7.05	12.60
Cloth Package	19.98	17.41	16.88	15.49	14.33	12.91	11.53	10.00	8.49	14.11
LSD 5%	NS	0.13	0.15	0.19	0.14	0.13	0.15	0.13	0.12	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	

Table 4: Averages of shoot length (cm), root length (cm), shoot fresh weight (mg), root fresh weight (mg), shoot dry weight (mg) and root dry weight (mg) as affected by storage periods.

Storage Periods (month)	Shoot length (cm)	Root length (cm)	Shoot fresh weight (mg)	Root fresh weight (mg)	Shoot dry weight (mg)	Shoot dry weight (mg)
0 (Pre-storage)	19.45	15.73	539.25	213.30	41.98	19.98
3 months	17.62	14.22	464.96	182.65	36.10	16.66
6 months	16.11	13.02	439.35	173.03	34.56	16.23
9 months	14.60	11.86	403.48	157.98	31.66	14.79
12 months	13.32	10.81	367.62	143.75	28.68	13.56
15 months	11.86	9.65	334.83	128.47	26.28	12.11
18 months	10.55	8.57	302.46	114.06	23.75	10.78
21 months	9.19	7.47	269.40	99.63	21.15	9.37
24 months	7.69	6.23	232.29	83.29	18.29	7.83
LSD 5%	0.07	0.06	1.93	0.77	0.16	0.08

storage periods from 3, 6, 9, 12, 15, 18, 21 and 24 months decreased shoot fresh weight by 13.78, 18.53, 25.18, 31.83, 37.91, 43.91, 50.04 and 56.92 %, respectively compared with shoot fresh weight before storage. Increasing storage periods from 3, 6, 9, 12, 15, 18, 21 and 24 months decreased root fresh weight by 14.37, 18.88, 25.94, 32.6, 39.77, 46.52, 53.29 and 60.95 %, respectively compared with root fresh weight before storage. Increasing storage periods from 3, 6, 9, 12, 15, 18, 21 and 24 months decreased shoot dry weight by 14.01, 17.69, 24.60, 31.69, 37.41, 43.43, 49.63 and 56.43 %, respectively compared with shoot dry weight before storage. Increasing storage periods from 3, 6, 9, 12, 15, 18, 21 and 24 months decreased root dry weight by 16.62, 18.77, 26.01, 32.12, 39.41, 46.03, 53.11 and 60.84 %, respectively compared with root dry weight before storage. 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[2]. In addition,[23] reported that total carbohydrate decreased and increase in lipid per oxidation and seed viability influenced during storage. These results are in good agreement with those reported by (Rai et al., 2011; Kandil et al., 2013; Belay et al., 2017; Strelec et al., 2010; Wambugu et al., 2009; Naguib et al., 2011; El-Abady 2014; Oskouei et al., 2014; Wani et al., 2014).

CONCLUSION

It could be concluded that increasing storage period is associated with decreases in all the studied seedling parameters. To maximize maize hybrids seedling parameters, it should be storage Giza 176 hybrid under refrigerator conditions (4°C±1) seeds in cloth bags up to 12 months.

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