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SEEDLING PARAMETERS OF SOYBEAN CULTIVARS AS INFLUENCED WITH SEED STORAGE PERIODS, CONDITIONS AND MATERIALS

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Abstract- This investigation was elucidated seedling characters effects of soybean cultivars i.e. Crawford, Giza 111, Giza 21, Giza 22 and Giza 35 due to ageing (storage) in different packaging material i.e. seeds or pods in plastic or cloth bags for different periods i.e. 3, 6, 9 and 12 months under ambient and refrigerator conditions. Seedling parameters i.e. root and shoot length, seedling fresh and dry weight root/shoot ratio and seedling vigor index were decreased with the period of ageing. Soybean cultivars are 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 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. Storage under refrigerator conditions at 10$^{\circ C}$ ± 1 exceeded storage under ambient conditions in root length, shoot length, root/shoot ratio and seedling fresh and dry weight and seedling vigor index. Results clearly showed that root and shoot length, root/shoot ratio, seedling fresh and dry weight and seedling vigor index significantly affected by the varies interactions.

Keywords- Soybean, cultivars, storage, viability, deterioration, seed vigor and periods

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Introduction

Soybean is one of the most important oil crops in the world agricultural economy as food for man. Seed deterioration is a serious problem in developing countries like Egypt where seeds are stored in places usually without a proper control of humidity and temperature. Seed storage conditions can regulate germination characteristics and vigor potential of seeds [14]. Reduction in seed vigor is due to decrease in seed quality, percentage, rate of germination can increase susceptibility to environmental stress [29]. Mc Donald [14] found that seed deterioration leads to decreases in seed quality, performance and stand establishment. Variations that occur in seed during aging are significant in terms of seed quality, among other things, also implies seed longevity [15]. The shoot and root length of seedling was lowest at the end of storage in cloth and the lowest seedling vigor. Balesevic-Tubic, et al. [4] showed that protection of seed viability depended on storage condition and duration. Khalilia-qdam, et al. [12] recommended that variations happened with the viability constants of a seed deterioration model between the soybean cultivars. Different periods of seed ageing and storage conditions adversely affected the seed vigor [27]. Arif, et al. [3] concluded seed viability gradually decreased from 64.5 to 39.2% as the time in storage increased, from 2 to 12 months Similar conclusions was reported by Sharma, et al. [24], Simic, et al. [25], Vijay, et al. [32].

Moreover, Arif, et al. [3], concluded that uppermost germination of seed stored at 40°C than ambient temperature. Similar results was indicated by Ghasemnezhad, et al. [8], Sharma, et al. [23], Simic, et al. [25], Vijay, et al. [32]. Mohammadi, et al. [16] incubated soybean seeds at two different temperatures of 34°C and 40°C for varying times. They indicated that seedling vigor and seedling parameters reduced by increasing storage temperature.

There were significant differences between soybean genotypes (Sb 1, Sb 2, Sb 3, Sb 4, Sb 5 and Sb 6) in seedling vigor index, shoot and root length. These changes between genotypes might be due to the genetic factors and seed chemical composition influence the expression of seed deterioration and vigor decline [28]. Khalilia-qdam, et al. [12] reported that preliminary viability was same (100%) among DPX and Sahar cultivars. Also, the vigor power i.e. electrical conductivity, seedling dry weight and seedling normal percentage had no significant difference between DPX and Sahar cultivars but in Sahar, values of all vigor trials except EC were higher than DPX and EC in Sahar was lower. Similar conclusions were reported by Kalavathi, et al. [10], Simic, et al. [25], Venkatareddy, et al. [31].

In case of dry weight per plant of soybean seed decreases all cases but the rate of weakening is highest in cloth bag [17]. Chuansin, et al. [6] reported that soybean seeds were stored in Metallized film bags and Aluminum foil bags observed highly typical germination and seed vigour, and keep water activity and seed moisture content in low level could delay seed quality deterioration followed by Polypropylene bags and woven bag. Tatipata, et al. [28] reported that soybean seeds were stored in aluminums foil bags observed highly seedling vigor and keep moisture content in low level could delay seed deterioration followed by polyethylene and wheat bags. Owolade, et al. [19] reported that sorghum seeds stored inside gene bank and freezer irrespective of the packaging materials and type of accession retain their viability to the tune of 90.67 to 100%. Whereas seeds stored at ambient temperature had low germination percentage (10.67 to 28.00%) except those stored in aluminum can (41.33%). Similar results was achieved by Arif, et al. [3], Charjan, et al. [5], Shanmugavel, et al. [22], Singh, et al. [26]. The objectives of this investigation was amid to study changes on seedling properties of some soybean cultivars under different storage condition, storage materials and periods and their interactions effect.

Materials and Methods

The experiment was conducted at experimental seed testing laboratory of Agronomy Department, Faculty of Agriculture, Mansoura University, Egypt during 2011 and 2012. The objectives of this investigation were aimed to study response of some soybean cultivars i.e. Giza 21, Giza 22, Giza 35, Giza 111 and Crawford to storage periods i.e. 3, 6, 9 and 12 months, storage conditions i.e. ambient conditions and refrigerator conditions at 10°C ±1 as well as storage materials i.e. seed with cloth bags, seed with plastic bags, pods with cloth bags and pods with plastic bags on seedling parameters.

Treatments and Experimental Design

The treatments were arranged in factorial experimental in completely randomize design, consisted of totally 160 treatments combinations involving tow storage conditions i.e. ambient conditions and refrigerator conditions at 10°C ±1, four different kinds of package materials i.e. seed with cloth bags, seed with plastic bags, pods with cloth bags and pods with plastic bags, four storage periods i.e. 3, 6, 9 and 12 months and five of soybean cultivars i.e. Giza 21, Giza 22, Giza 35, Giza 111 and Crawford. Soybean (*Glycine Max* L. Merr) cultivars were harvested in October 2011, cleaned from dust and dirt then dried and processed for storage. Every three months, from a total 12 months of storage, germination characters, electrical conductivity, acidity number, peroxide number, oil content and moisture content were evaluated.

Studied Characteristics

The following seedling parameters were studied as following:

1. **Root length (cm):** Ten normal seedlings were randomly selected in each petri dishes from final count and the root length was determined from the collar region to the tip of the primary root. The average root length of ten seedlings was computed and expressed in centimeter.
2. **Shoot length (cm):** Ten seedlings used for root length were used for shoot length measurement. The length between the collar region and the tip of the primary shoot was considered as shoot length and it was measured. The mean value of shoot length was calculated and expressed in centimeter.
3. **Root/ shoot ratio:** The root/shoot ratio was computed according to Harris, et al. [9], the root/shoot ratio is the ratio of the length of root divided on the length of the shoot.
4. **Seedling dry weight (g):** Ten seedlings used for measuring the seedling were also utilized for determining the dry weight of the seedling. Seedlings were dried in hot air oven maintained at 70±1°C for 24 hr. and then at 105°C until constant dry weight. After drying, seedlings were kept in desiccators for cooling and further weighed and expressed in grams.
5. **Seedling fresh weight (g):** Ten seedlings used for measuring seedling length were also utilized for determining the fresh weight of the seedling expressed in grams.
6. **Seedling vigor index:** Seedling vigor index was computed by adopting the formula as suggested by Abdul-baki, et al. [9] and expressed in whole number.

Vigor Index = Germination (%) x [(Shoot Length + Root Length)]

Results and Discussion

Storage Periods Effects

The results showed a significant effect of storage periods on the means of root length, shoot length, seedling dry weight, seedling fresh weight and seedling vigor index [Table-1]. The results showed that root length, shoot length, root /shoot ratio, seedling fresh and dry weight and seedling vigor index were decreased as storage periods were increased. Results revealed that before storage treatments significantly exceeded the other storage periods in root length, shoot length, root/shoot ratio, seedling fresh and dry weight and seedling vigor index followed by after 3 months. While, after 12 months from storage recorded lowest root length, shoot length, root /shoot ratio, seedling dry and fresh weight and seedling vigor index. It could be concluded that increasing storage periods from 3, 6, 9 and 12 months decreased root length by 7.73, 8.63, 13.34 and 22.08 %, respectively compared with root length before storage. Increasing storage periods from 3, 6, 9 and 12 months decreased shoot length by 5.94, 8.72, 13.27 and 21.99 %, respectively compared with shoot length before storage. Increasing storage periods from 3, 6, 9 and 12 months decreased seedling dry weight by 2.23, 3.91, 15.08 and 22.90 %, respectively compared with seedling dry weight before storage. Increasing storage periods from 3, 6, 9 and 12 months decreased seedling fresh weight by 5.01, 5.35, 9.23 and 13.34 %, respectively compared with seedling fresh weight before storage. Increasing storage periods from 3, 6, 9 and 12 months decreased seedling vigor index by 9.30, 14.24, 25.35 and 38.28 %, respectively compared with seedling vigor index before storage. In this regard, Manomani, et al. [9] reported that the decline in root length, shoot length, seedling dry and fresh weight and seedling vigor index with increase of storage periods might be due to their genetic differences age induced deterioration, inherent differences in seed structure and composition. In addition, Mohammadi, et al. [9] reported that seed deterioration results in decreased percentage of normal seedlings. Seedling growth and the fraction of seed reserve mobilization indicated a significant reduced with the advance of deterioration. Decrease of seed quality is connected with biochemical changes in seeds of oil crops. These seeds had a quick deterioration due to auto oxidation of lipids and the increase of the content of free fatty acids during storage period. The longer seeds storage period increases intensity of seeds aging [6]. These results are in good agreement with those reported by Arefi, et al. [2], Keshavulu, et al. [11], Khaliliaqdam, et al. [12], Sharma, et al. [24], Tatic, et al. [27].

Storage Cultivars Effects

Results revealed that Giza 111 cultivar significantly exceeded the other studied cultivars in root length, shoot length, root/shoot ratio and seedling vigor index. While, Giza 35 surpassed the other cultivars in seedling dry and fresh weight as shown in [Table-1]. Giza 21 cultivar recorded the lowest root length, shoot length, seedling dry and fresh weight and seedling vigor index. While, Giza 35 recorded the lowest root/shoot ratio. Giza 111 surpassed Giza 21, Giza22, Giza 35 and Crawford cultivars in root length by 33.96, 33.56, 21.40 and 9.54 %, respectively. Giza 111 surpassed Giza 21, Giza 22 and Giza 35 cultivars in shoot length by 36.39, 36.39 and 7.77 %, respectively. Giza 111 surpassed Giza 21, Giza 22, Giza 35 and Crawford cultivars in root/shoot ratio by 3.38, 3.38, 15.25 and 9.32 %, respectively. Giza 111 surpassed Giza 21, Giza 22, Giza 35 and Crawford cultivars in seedling vigor index by 40.20, 40.08, 16.22 and 12.19 %, respectively. Giza 35 surpassed Giza 21, Giza 22, Giza 111 and Crawford cultivars in seedling dry weight by 15.25, 11.29, 3.38 and 8.47 %, respectively. Giza 35 surpassed Giza 21, Giza 22, Giza 111 and Crawford cultivars in seedling fresh weight by 10.48, 5.76, 5.99 and 5.99 %, respectively. In this respect, Tatic, et al. [27] stated that there was significant differences between soybean genotypes. These differences between genotypes might be due to the genetic factors and seed chemical composition influence the expression of seed deterioration and vigor decline. Moreover, El-Abady, et al. [7] stated that assessment of some soybean cultivars seed quality during storage by monitoring germination and germination after storage percentages, in addition to seed and seedling vigor measurements may be reliable indicators for damages occurred after mechanical threshing method. These results are in good accordance with those obtained by Khaliliaqdam, et al. [12], Muhammad, et al. [18], Sharma, et al. [24].

Table 1- Averages of root length (cm), shoot length (cm), root/shoot ratio, seedling dry and fresh weight and seedling vigor index as affected by storage periods, soybean cultivars, storage conditions, package materials and their interactions.

Treatments / Characters	Root length (cm)	Shoot length (cm)	Root / shoot Ratio	Seedling dry weight (g)	Seedling fresh weight (g)	Seedling vigor index
S- Storage periods (months)						
Before storage	8.92	7.91	1.15	0.179	0.877	1601
3 months	8.23	7.44	1.14	0.175	0.833	1452
6 months	8.15	7.22	1.14	0.172	0.83	1373
9 months	7.73	6.86	1.14	0.152	0.796	1195
12 months	6.95	6.17	1.13	0.138	0.76	988
LSD 5%	0.22	0.1	NS	0.0042	0.013	153.6
V-Soybean cultivars						
Giza 21	6.57	5.4	1.22	0.15	0.777	1010
Giza 22	6.61	5.4	1.22	0.157	0.818	1012
Giza 35	7.82	7.83	1	0.177	0.868	1415
Giza 111	9.95	8.49	1.18	0.171	0.816	1689
Crawford	9.03	8.48	1.07	0.162	0.816	1483
LSD 5%	0.22	0.1	0.04	0.004	0.013	153.6
C-Storage conditions						
Ambient conditions	7.77	7.05	1.12	0.162	0.792	1252
Refrigerator conditions (10°C±1)	8.22	7.19	1.15	0.164	0.847	1391
F- test	**	**	*	NS	**	**
P-Package materials						
Pods in plastic bags	7.88	7.04	1.14	0.162	0.822	1273
Pods in cloth bags	8.17	7.25	1.14	0.163	0.821	1415
Seed in plastic bags	7.9	7.14	1.12	0.163	0.812	1322
Seed in cloth bags	8.03	7.05	1.16	0.166	0.822	1277
LSD 5%	0.17	0.11	NS	NS	NS	NS
F-test Interactions						
V×S	**	**	NS	**	**	NS
S×C	**	**	NS	**	**	NS
V×C	**	**	**	**	NS	NS
V×C×S	NS	**	NS	**	NS	NS
S×P	NS	**	NS	NS	NS	NS
V×P	NS	**	**	**	**	NS
V×S×P	NS	NS	NS	NS	NS	NS
C×P	**	NS	*	NS	NS	*
S×C×P	NS	NS	NS	NS	NS	NS
V×C×P	*	NS	NS	**	**	NS
V×C×S×P	*	NS	*	NS	NS	NS

Storage Conditions Effects

The results showed that a significant effect of storage conditions on the average of root length, shoot length, root/shoot ratio, seedling fresh weight and seedling vigor index [Table-1]. The results clearly indicated that storage under refrigerator conditions at 10°C surpassed ambient conditions in root length, shoot length, root/shoot ratio by 5.47, 1.94, 2.60, 5.50 and 9.99 %, respectively. Ageing process is affected by the genetic factors [30]. Meanwhile, Rai, et al. [21] 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. These results are in good harmony with those obtained by Arefi, et al. [2], Chuansin, et al. [6], Khaliliaqdam, et al. [12], Muhammad, et al. [18].

Storage Package Materials Effects

The results showed that a significant effect of package materials on the means of root length and shoot length [Table-1]. The results showed that root length significantly affected by package materials. Highest root length obtained from storage soybean pods in cloth bags followed by storage seed in cloth bags. However, the lowest root length obtained from storage soybean pods or seed in plastic bags without significant differences between them. Tallest shoot was obtained from storage soybean pods in plastic bags and seed in cloth bags. However, shortest shoot was obtained from storage soybean cultivars seed in cloth bags or pods in plastic bags. In this respect, Panobianco, et al. [20] stated that both the packaging materials, seedling parameters were found more affected in plastic bags as compared to jute bags in both the inbred lines of maize. Vigor percentage decreased with the period of storage. Inbred are stored in plastic bags were affected due to storage but the effects were more pronounced in the plastic bags as compared to jute bags. These results are in harmony with those reported by Arefi, et al. [2], Khaliliaqdam, et al. [12].

Interaction Effects

Interaction between Soybean Cultivars and Storage Periods

The results clearly indicated that pre storage of Giza 111 cultivar recorded the tallest roots followed by storage Giza 111 after 3 and 6 months without significant differences between them [Fig-1]. The lowest root length was recorded from storage Giza 21 and Giza 22 cultivars after 12 months without significant differences between them. The results clearly indicated that tallest shoots was produced from pre storage treatments of Giza 111 and Crawford cultivars followed by storage Crawford or Giza 111 cultivars for 3 months recorded highest shoot length. The shortest shoot was recorded from storage Giza 21 and Giza 22 cultivars after 12 months without significant differences between them [Fig-2]. The results clearly indicated that heaviest seedling dry weight was recorded from pre storage of Giza 111 cultivar followed with Crawford and storage Giza 35 after 3 months. The lowest seedling dry weight was recorded from storage Giza 21 cultivar after 12 months [Fig-3]. The results clearly indicated that highest seedling fresh weight was obtained from Giza 35 cultivar before storage followed by storage Giza 35 after 3, 6 and 9 months without significant differences between them. The lowest seedling fresh weight was recorded from storage Giza 21 cultivar after 12 months [Fig-4]. These results in agreement with those obtained by Arefi, et al. [2], Balesevic, et al. [4], Khaliliaqdam, et al. [12], Monira, et al. [17], Muhammad, et al. [18], Panobianco, et al. [20], Tatic, et al. [27].

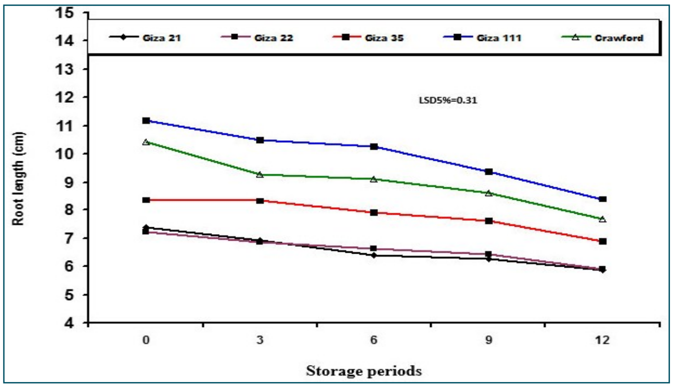

Fig. 1- Averages of root length (cm) as affected by the interaction between soybean cultivars and storage periods

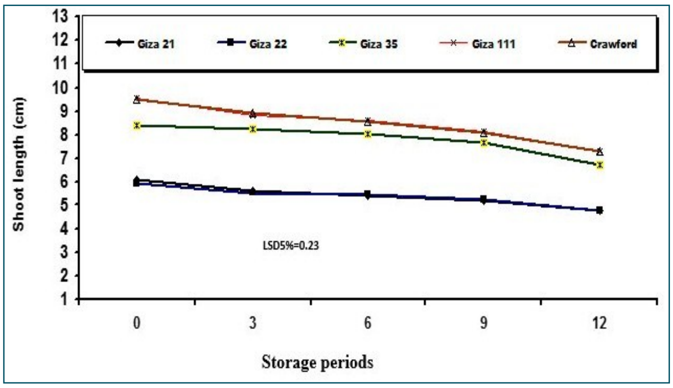

Fig. 2- Averages of shoot length (cm) as affected by the interaction between soybean cultivars and storage periods

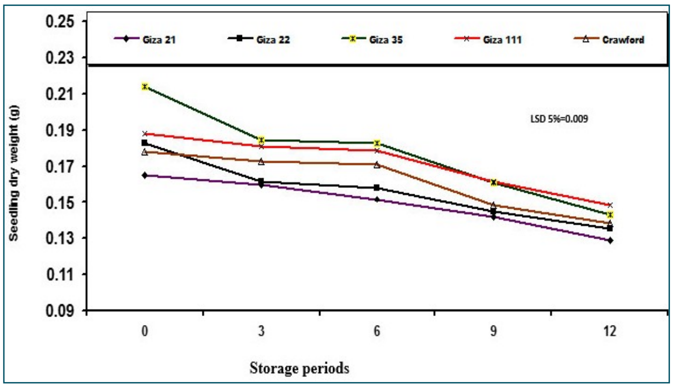

Fig. 3- Averages of seedling dry weight (g) as affected by the interaction between soybean cultivars and storage periods

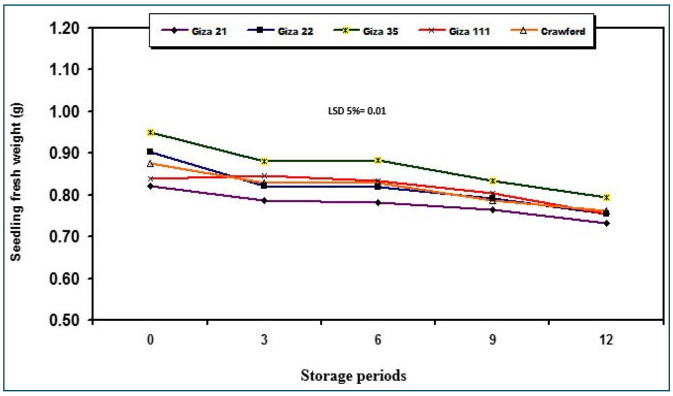

Fig. 4- Averages of seedling fresh weight (g) as affected by the interaction between soybean cultivars and storage periods

Interaction between Storage Periods and Storage Conditions Effects

The results clearly indicated that clearly indicated that root length significantly differed due to the interaction between storage periods and storage conditions. Storage under refrigerator conditions at 10° C for 3 or 6 months recorded highest root length without significant differences between them [Fig-5]. Storage under ambient conditions for 3 months came in the second rank. Shortest root was obtained from storage under ambient conditions for 12 months. The results clearly indicated that that shoot length significantly differed due to the interaction between storage periods and storage conditions [Fig-6].

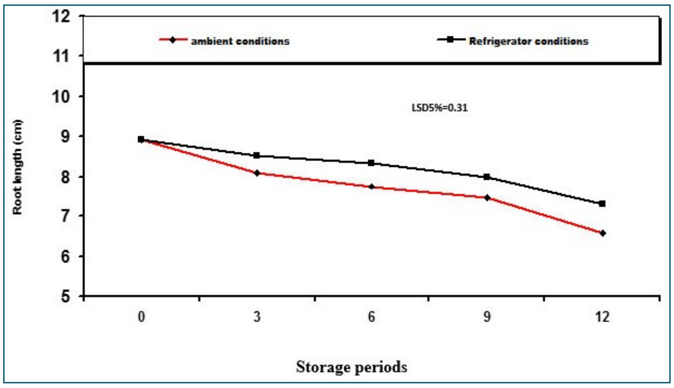

Fig. 5- Averages of root length (cm) as affected by the interaction between storage conditions and storage periods.

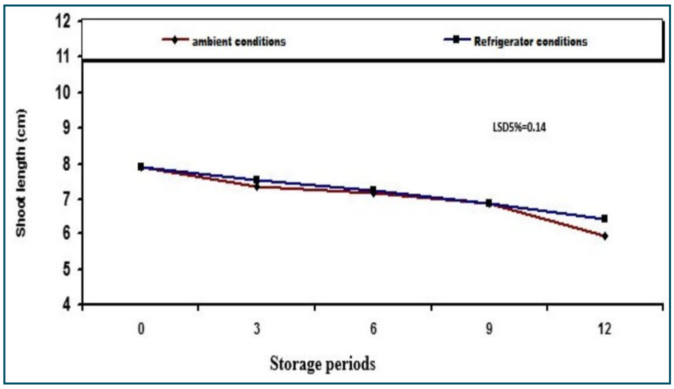

Fig. 6- Averages of shoot length (cm) as affected by the interaction between storage conditions and storage periods

It could be noticed that tallest shoots was produced from pre storage treatments followed by soybean storage under refrigerator conditions at 10°C for 3 months. The shortest shoot was obtained from storage under ambient for 12 months. The results clearly indicated that seedling dry weight significantly differed due to the interaction between storage periods and storage conditions [Fig-7]. It could be noticed that pre storage treatment recorded heaviest seedling dry weight followed by the storage under refrigerator conditions at 10°C for 3 months. Storage under ambient conditions for 3 months came in the second rank. The lowest seedling dry weight was obtained from storage under ambient for 12 months. The results clearly indicated that seedling fresh weight differed significantly due to the interaction between storage periods and storage conditions [Fig-8]. It could be noticed that pre storage treatment recorded highest seedling fresh weight followed by storage under refrigerator conditions at 10°C for 3 or 6 months without significant differences between them. Storage under ambient conditions for 3 months came in the second rank. The lowest seedling fresh weight was obtained from storage in ambient for 12 months. These results are in conformity with those reported by Arefi, et al. [2], Khaliliaqdam, et al. [12], Mohammadi, et al. [16], Panobianco, et al. [20], Sharma, et al. [24], Tatic, et al. [27].

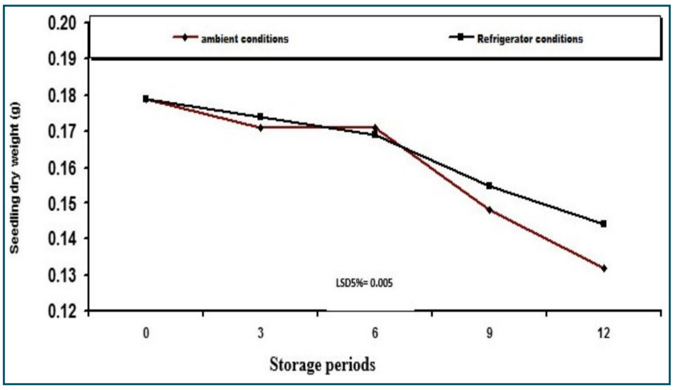

Fig. 7- Averages of seedling dry weight (g) as affected by the interaction between storage conditions and storage periods

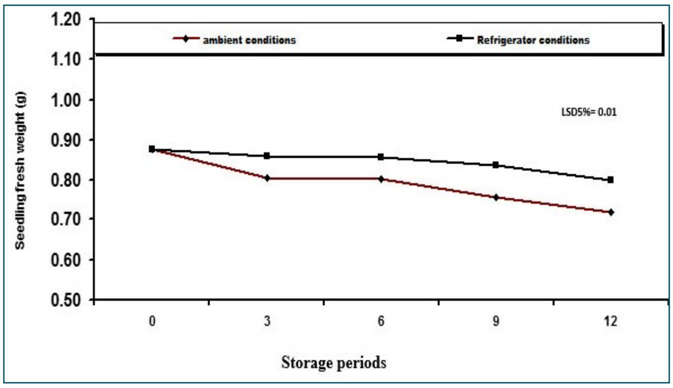

Fig. 8- Averages of seedling fresh weight (g) as affected by the interaction between storage conditions and storage periods

Interaction between Soybean Cultivars and Storage Conditions Effects

The results clearly indicated that root length significantly affected due to the interaction between soybean cultivars and storage conditions [Fig-9].

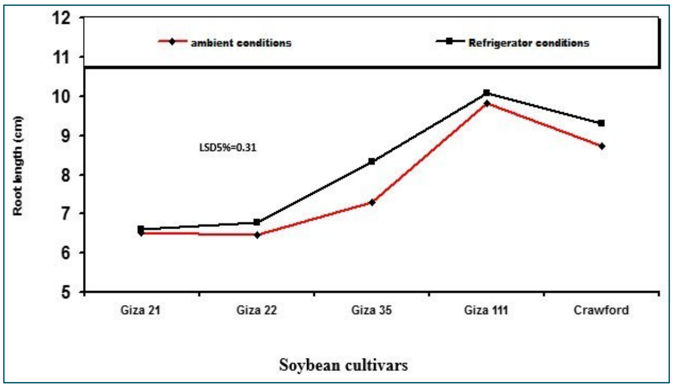

Fig. 9- Averages of root length (cm) as affected by the interaction between soybean cultivars and Storage conditions

The results clearly indicated that highest root length was obtained from storage Giza 111 cultivar in refrigerator conditions (10°C±1) followed by Crawford cultivar. The shortest root was obtained from storage Giza 21 and Giza 22 under ambient conditions without significant differences between them. The results clearly showed that shoot length significantly affected due to the interaction between soybean cultivars and storage conditions [Fig-10]. The results clearly showed that highest shoot length was obtained from storage Giza 111 cultivar in refrigerator conditions (10°C±1) followed by Crawford cultivar without significant differences between them. The shortest shoot was obtained from storage Giza 21 and Giza 22 cultivars in ambient conditions without significant differences between them. The results clearly indicated that root/shoot ratio significantly affected due to the interaction between soybean cultivars and storage conditions [Fig-11].

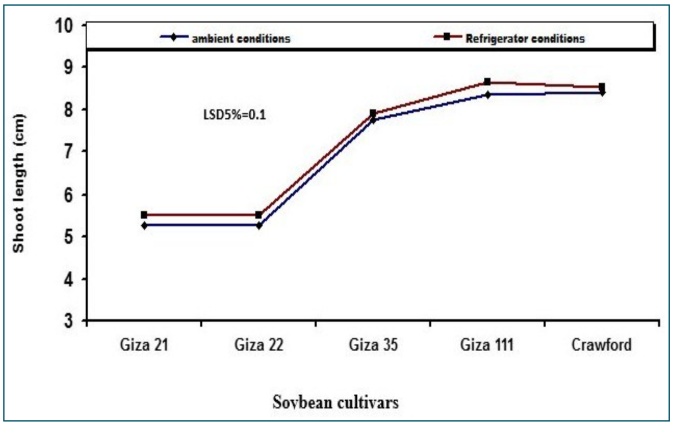

Fig. 10- Averages of shoot length (cm) as affected by the interaction between soybean cultivars and Storage conditions.

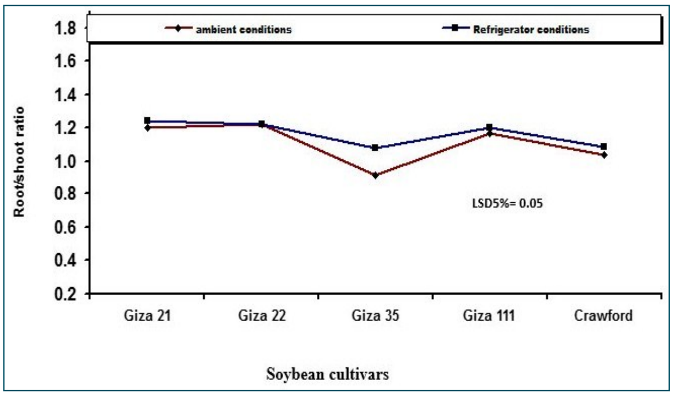

Fig. 11- Average root/shoot ratio as affected by the interaction between soybean cultivars and Storage conditions.

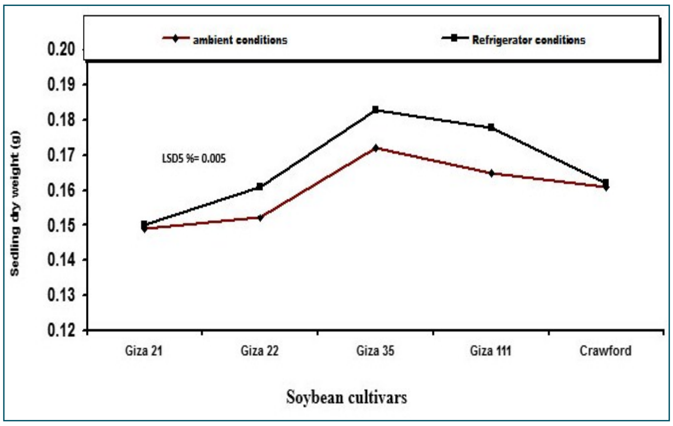

Fig. 12- Averages of seedling dry weight (g) as affected by the interaction between soybean cultivars and Storage conditions

It could be noticed that highest root/shoot ratio was obtained from storage Giza 21 in refrigerator conditions (10°C±1) followed by Giza 22 cultivars without significant differences between them. The lowest root/shoot ratio was obtained from storage Giza 35 under ambient conditions. The results clearly indicated that seedling dry weight significantly affected due to the interaction between soybean cultivars and storage conditions [Fig-12]. The results clearly showed that highest seedling dry weight was obtained from storage Giza 35 cultivar in refrigerator conditions (10°C±1) followed by Giza111 cultivar. The lowest seedling dry weight was obtained from storage Giza 21 and Giza 22 under ambient conditions without significant differences between them. These results are in conformity with those reported by Arefi, et al. [2], Khaliliaqdam, et al. [12], Mohammadi, et al. [16], Panobianco, et al. [20], Tatic, et al. [27].

Interaction between Storage Periods, Soybean Cultivars and Storage Conditions

The results clearly showed significant interaction between storage periods × soybean cultivars × storage conditions on shoot length [Fig-13]. It could be noticed that pre storage treatment recorded tallest shoot of Giza 111 or Crawford cultivar followed by storage Giza 111 and Crawford in refrigerator conditions at 10°C for 3 months. However, shortest shoots was produced from storage Giza 21 and Giza 22 cultivars under ambient or refrigerator conditions for 12 months without significant differences between them. The results clearly showed significant interaction on seedling dry weight between storage periods × soybean cultivars × storage conditions [Fig-14].

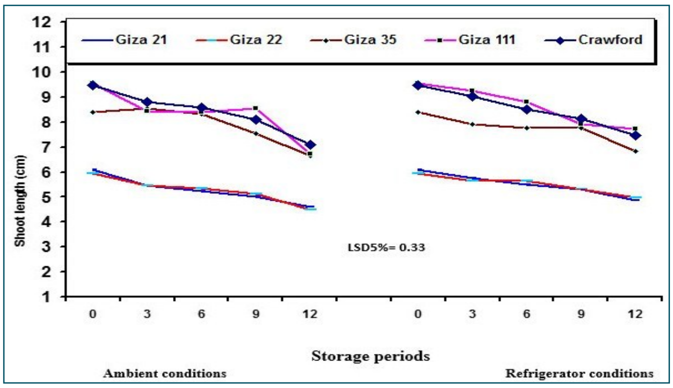

Fig. 13- Averages of shoot length (cm) as affected by the interaction between storage periods, soybean cultivars and Storage conditions.

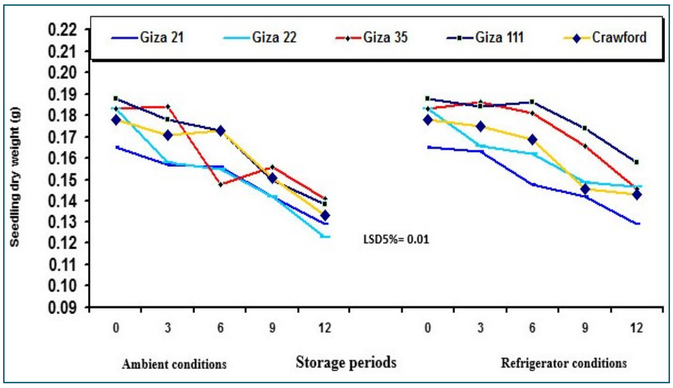

Fig.14- Averages of seedling dry weight (g) as affected by the interaction between storage periods, soybean cultivars and Storage conditions

It could be noticed that pre storage of Giza 111 cultivar recorded heaviest seedling dry weight followed by storage Giza 35 and Giza 111 under refrigerator conditions at 10°C for 3 months. However, the lowest seedling dry weight were produced from storage Giza 22 under ambient conditions for 12 months and or Giza 21 under ambient or refrigerator conditions at 10°C without significant differences between them. These results are in good agreement with those reported by Balesevic, et al. [4], Tatic, et al. [27].

Interaction between Storage Periods and Package Materials

The results clearly indicated that shoot length significantly affected due to the interaction between storage periods and package materials [Fig-15]. It could be noticed that tallest shoots was obtained from pre storage treatment followed by storage soybean cultivars seeds in plastic bags for 3 months. The shortest shoots was obtained from storage soybean pods in plastic bags for 12 months. These results are in conformity with those reported by Arefi, et al. [2], Khaliliaqdam, et al. [12], Mohammadi, et al. [16], Panobianco, et al. [20], Sharma, et al. [24], Tatic, et al. [27].

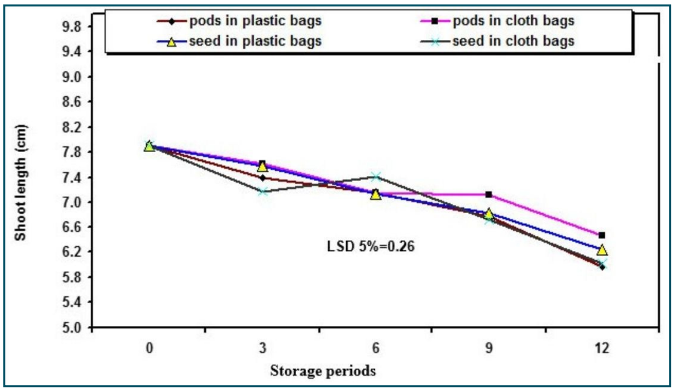

Fig. 15- Averages of shoot length (cm) as affected by the interaction between storage periods and package materials

Interaction between Soybean Cultivars and Package Materials

The results clearly indicated that shoot length significantly differed due to the interaction between soybean cultivars and packages materials [Fig-16]. The results clearly showed that the tallest shoots were produced from storage Giza 111 pods in cloth bags. The shortest shoots were obtained from storage Giza 21 or Giza 22 pods in plastic bags or cloth bags, as well as seed in plastic bags or cloth bags without significant differences between them. The results clearly indicated that highest root/shoot ratio were produced from storage Giza 22 seeds in plastic or cloth bags without significant differences between them [Fig-17]. The lowest root/shoot ratio were obtained from storage Giza 35 seeds or pods in plastic bags without significant differences between them. The results clearly indicated that highest seedling dry weight were produced from storage Giza 35 pods in plastic bags [Fig-18]. The lowest seedling dry weight were obtained from storage Giza 21 pods in plastic bags or in cloth bags and seed in plastic bags without significant differences between them. The results clearly indicated that highest seedling fresh weight were produced from storage Giza 35 seeds or pods in plastic bags without significant differences between them [Fig-19]. The lowest seedling fresh weight was obtained from storage Giza 21 pods or seeds in plastic or cloth bags without significant differences between them. These results are in conformity with those reported by Khaliliaqdam, et al. [12], Sharma, et al. [24], Tatic, et al. [27].

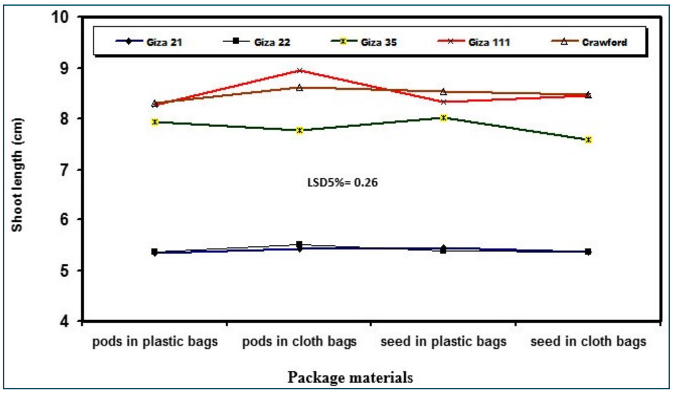

Fig. 16- Averages of shoot length (cm) as affected by the interaction between soybean cultivars and package materials.

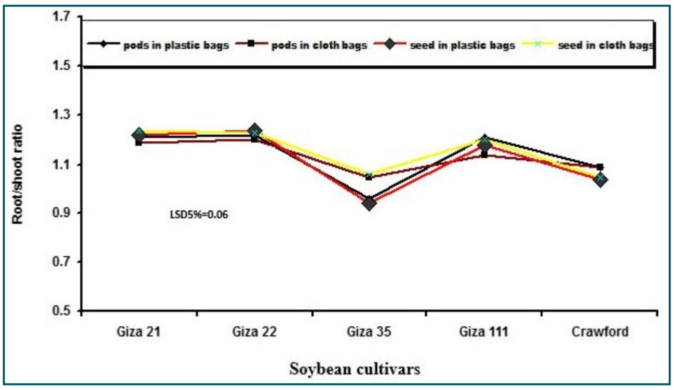

Fig. 17- Averages of root/shoot ratio as affected by the interaction between soybean cultivars and package materials.

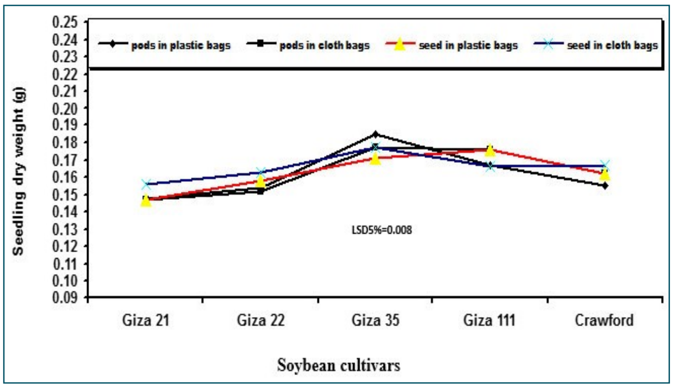

Fig. 18- Averages of seedling dry weight (g) as affected by the interaction between soybean cultivars and package materials.

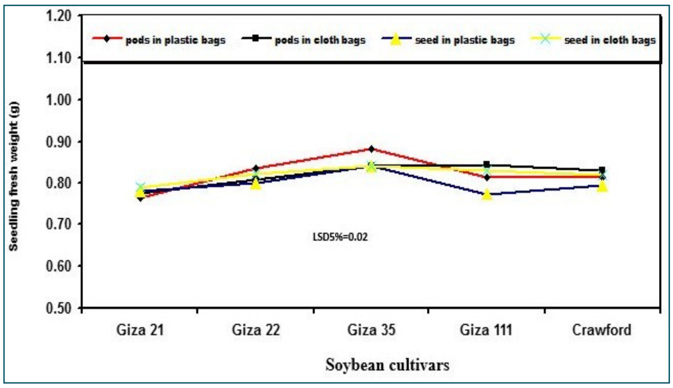

Fig. 19- Averages of seedling fresh weight (g) as affected by the interaction between soybean cultivars and package materials

Interaction between Storage Conditions and Package Materials

Root length due to the interaction effect between storage conditions and package materials showed significant effects on root length [Fig-20]. Highest root length was obtained from storage soybean pods or seeds in cloth bags under refrigerator conditions at 10°C without significant differences between them. However, the shortest root were obtained from storage soybean seeds in cloth bags and pods in plastic bags under ambient conditions without significant differences. The results clearly showed that highest root/shoot ratio were obtained from storage both soybean cultivars seeds or pods in cloth bags under refrigerator conditions at 10°C without significant differences between them [Fig-21].

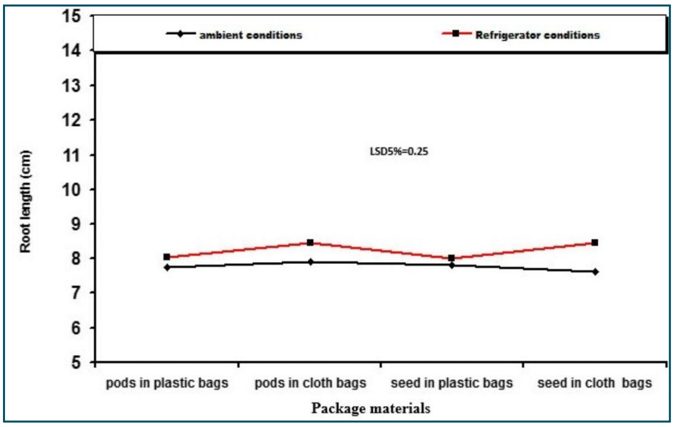

Fig. 20- Averages of root length (cm) as affected by the interaction between storage conditions and package materials.

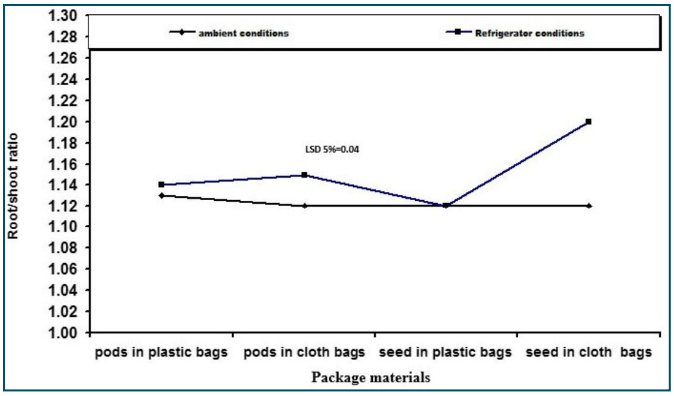

Fig. 21- Averages of root/shoot ratio as affected by the interaction between storage conditions and packages materials.

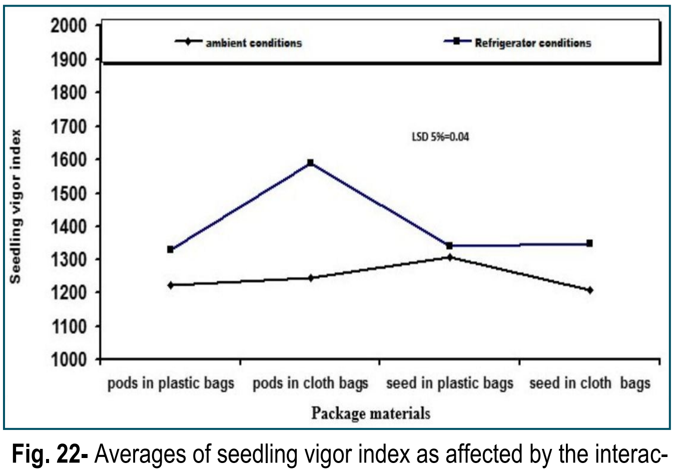

Fig. 22- Averages of seedling vigor index as affected by the interaction between storage conditions and packages materials

However, the lowest root/shoot ratio were obtained from storage soybean cultivars pods or seeds in cloth bags and seeds in plastic bags under ambient conditions without significant differences. The results clearly indicated that highest seedling vigor index was obtained from storage soybean pods in cloth bags under refrigerator conditions (10°C±1). However, the lowest seedling vigor index was obtained from storage soybean as pods or seed in plastic or cloth bags under ambient conditions without significant differences [Fig-22]. These results in good harmony with those reported by Khaliliaqdam, et al. [12], Muhammad, et al. [18], Sharma, et al. [24], Tatic, et al. [27].

Interaction between Soybean Cultivars, Storage Conditions and Package Materials

The results clearly indicated that tallest root was obtained from storage Giza 111 when storage in refrigerator conditions as pods or seeds in cloth bags followed by Crawford cultivar when storage in pods or seeds in cloth bags [Fig-23]. Shortest root was obtained from storage Giza 21 under ambient conditions or under refrigerator in pods or seeds in cloth bags or plastic bags followed by Giza 35 cultivar as pods or seed in plastic or cloth bags, in refrigerator conditions or in ambient conditions. The results clearly indicated that highest seedling dry weight was obtained from storage Giza 35 cultivar under refrigerator conditions pods in plastic or cloth bags followed by Giza 111 cultivar pods or seeds in Cloth or plastic bags [Fig-24].

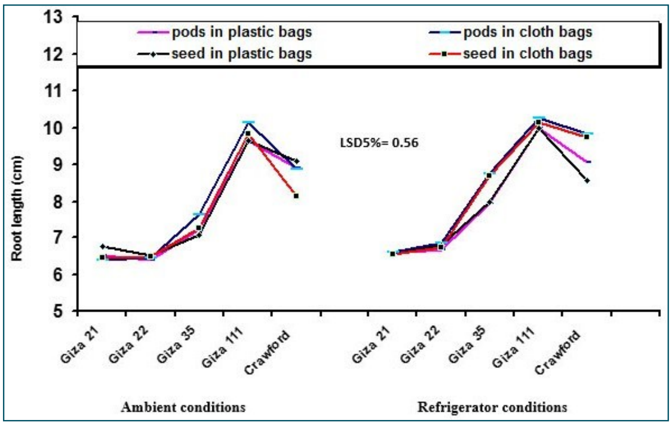

Fig. 23- Averages of root length (cm) as affected by the interaction between soybean cultivars, storage conditions and package materials.

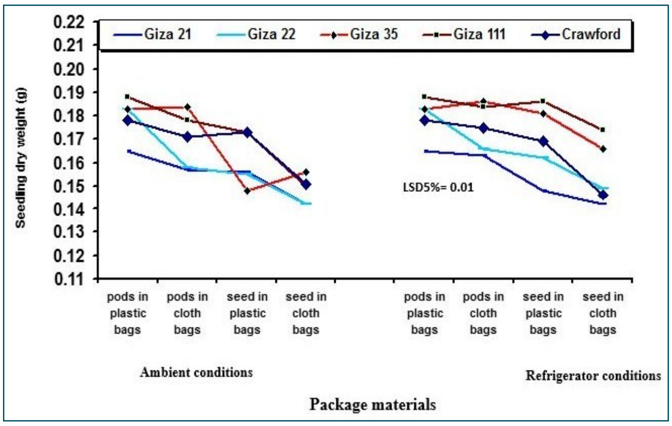

Fig. 24- Average seedling dry weight (g) as affected by the interaction between soybean cultivars, storage conditions and package materials.

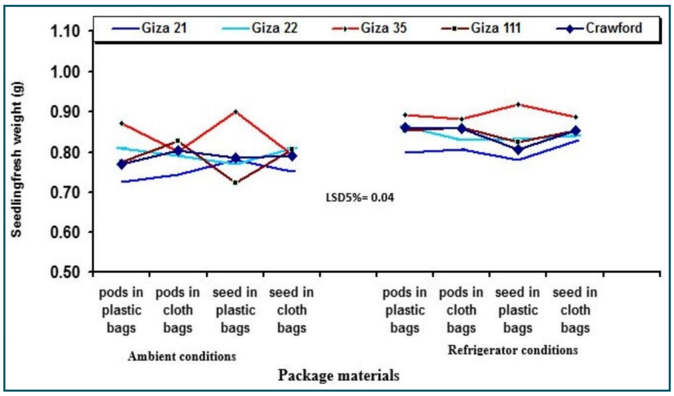

Fig. 25- Average seedling fresh weight (g) as affected by the interaction between soybean cultivars, storage conditions and package materials

Lowest seedling dry weight was obtained from storage Giza 21 cultivar under ambient conditions pods or seeds in plastic or cloth bags. The results clearly indicated that highest seedling fresh weight was obtained from storage Giza 35 cultivar under refrigerator conditions of soybean seed or pods in plastic or cloth bags without significant differences between them [Fig-25]. Lowest seedling fresh weight was obtained from storage Giza 21 cultivar under ambient conditions of soybean pods in plastic bags or soybean seed in plastic or cloth bags without significant differences between them. These results in agreement with those obtained by Arefi, et al. [2], Khaliliaqdam, et al. [12], Mohammadi, et al. [16], Muhammad, et al. [18], Tatic, et al. [27].

Conclusion

This investigation was revealed that for maximizing soybean viability and seedling parameters, it should be storage Giza 111 cultivar under refrigerator conditions (10°C±1) pods or seeds in cloth bags for 3 months.

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