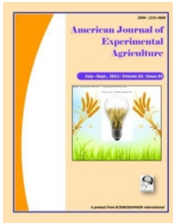

American Journal of Experimental Agriculture
3(4): 1020-1043, 2013

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Effect of Seed Storage Periods, Conditions and Materials on Germination of Some Soybean Seed Cultivars

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Authors' contributions

This work was carried out in collaboration between all authors. Authors AAK, AES designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author MSS managed the analyses of the study. Authors AAK, AES and MSS read and approved the final manuscript.

Research Article

Received 5th March 2013
Accepted 29th May 2013
Published 25th September 2013

ABSTRACT

Aims: This investigation aimed to study response of some soybean CVS, 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 ± 1ºC as well as storage materials, on germination characters.
Study Design: Treatments were arranged in factorial experimental in completely randomize design, consisted of totally 160 treatments combinations involving tow storage conditions, i.e. ambient and refrigerator conditions at 10 ± 1ºC, four different 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 CVS, i.e. Giza 21, Giza 22, Giza 35, Giza 111 and Crawford.
Place and Duration of Study: Laboratory experiment was conducted in Agronomy Department, Fac. of Agric. Mansoura Univ., Egypt during 2011 and 2012.
Methodology: Soybean CVS were harvested in October 2011, cleaned, then dried and processed for storage. Every three months, from a total 12 months of storage, germination characters were evaluated.
Results: Seed germination characters were decreased with increasing period of ageing. Giza 111 exceeded other CVS in energy of germination, emergence rate. Giza 21 cultivar exceeded other CVS in germination index. Giza 35 cultivar exceeded other CVS in final

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germination percentage. Storage under refrigerator conditions at 10 ± 1ºC surpassed under ambient conditions in final germination percentage, germination index, energy of germination, emergence rate. Energy of germination significantly affected by storage materials. Final germination percentage, germination index, energy of germination and emergence rate significantly affected by the varies interactions.
Conclusion: It could be concluded that storage Giza 111 cultivar under refrigerator conditions (10 ± 1ºC) of soybean seed with cloth bags for 3 months enhanced germination properties.

Keywords: Soybean; storage; viability; deterioration; seed viability and storage periods.

1. INTRODUCTION

Storage conditions and duration are important factors affecting germination parameters. Seed vigor is used as a measure of accumulated damage in seed as viability declines. Preservation of seed viability depended on storage condition and duration [1]. The decline of germination is much more acute under tropical conditions. These environmental conditions make very difficult to maintain its viability during storage [2]. Seed deteriorated during storage is one of the basic reasons for low productivity in soybean. Changes that occur in seed during ageing are significant in terms of seed quality among other things, also implies seed longevity [3]. Different periods of seed storage, as well as ageing conditions adversely affected the seed vigor [4]. Arif et al. [9] concluded that seed viability gradually decreased from 64.5 to 39.2% as the time of storage increased, from 2 to 12 months. Changes occurring in seed during ageing are very significant with regard to quality and longevity of seed. Seed composition characteristics of oily plants are related to specific processes occurring in seed during storage [5].

The soybean seed generally deteriorated with storage and deterioration was particularly strong for grains stored with initial moisture contents of 12.8 and 14.8 % at 40ºC. The grains stored with initial moisture contents of 14.8 % at 30 and 40ºC were classified as out of market standard after 135 and 90 days respectively [6]. Differences in oil percentage that affected by storage longevity were significant among tested crops and genotypes. Storage longevity was negatively associated with oil content. At storage conditions at 12ºC/60%, decreasing of seed oil content than in storage conditions at 25ºC/75% [7]. In addition, [3] and [1] showed that preservation of seed viability depended on storage condition and duration. Khaliliaqdam et al. [8] suggested that variations occurred with the viability constants of a seed deterioration model between the soybean cultivars. Different periods of seed storage, as well as storage conditions adversely affected the seed vigor [8]. Similar conclusions was reported by [8,10,11]. Seed stored at 4ºC recorded highest germination percentage than ambient temperature [9]. Similar results was indicated by [5,12,13]. Vijay et al. [11] incubated soybean seeds at two different temperatures of 34ºC and 40ºC for varying times. They indicated that soybean viability decreased by increasing storage temperature.

Regarding to storage materials, [14] stated that storability of soybean cultivars could be enhanced by four months after storing seed in polythene bag compared to cloth bag. Singh et al. [15] reported that soybean seeds stored in cloth bag maintained satisfactory germination only for 4 months of storage. Wheat seed stored in gunny, cloth and plastic bags were in good moisture content levels and recorded higher germination percentage in comparison with those stored in metal and earthen bins [17]. 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 except those stored in aluminum can [18].

A significant differences between soybean genotypes (Sb1, Sb2, Sb3, Sb4, Sb5 and Sb6) in final germination percentage, germination index and emergence rate after seed ageing. These differences between genotypes might be due to the genetic factors and seed chemical composition influence the seed manifestation and vigor [4]. Khaliliaqdam et al. [8] reported that initial viability was same 100% among DPX and Sahar cultivars. Also, the vigor power, i.e. final germination percentage had no significant difference between DPX and Sahar cultivars but in Shahar, values of all vigor trials. Soybean germination and vigor varied among cultivars and M-351 had the highest mean germination parameters [16]. Similar conclusions were reported by [7,19,20]. Sorghum seeds stored inside gene bank and freezer irrespective of the packaging materials and type of accession retain their viability. Whereas seeds stored at ambient temperature had low germination percentage except those stored in aluminum [18]. Similar results was obtained by [9,24,25]. The objective of this research was to determine the effects of storage period, storage conditions and materials on seed germination parameters of different soybean cultivars.

2. MATERIALS AND METHODS

A laboratory 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 ± 1ºC 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 germination characters.

2.1 Treatments and Experimental Design

Treatments were arranged in factorial experimental in completely randomize design, consisted of totally 160 treatments combinations involving tow storage conditions, i.e. ambient conditions (27ºC and RH 90 %) and refrigerator conditions at 10 ± 1ºC, 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 which 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 were evaluated.

2.2 Studied Characteristics

The following germination characters were studied as following:

2.3 Final Germination Percentage

Final germination percentage test was conducted as per the procedure prescribed in ISTA rules [26]. Hundred seeds in four replications were kept for germination in rolled rowels in a germinator maintained at 25 ± 7ºC and 95 % relative humidity. The normal seedlings was counted, 5th and 8th day. Then final germination percentage was calculated according to [27 and 28] as the follows equation:

$$\text{Final germination percentage} = \frac{\text{Number of normal seedlings}}{\text{Number of seeds}} \times 100$$

2.4 Germination Index (GI)

Germination index was calculated as described by [29] as the following formulae:

$$(GI) = \frac{\%\ \text{Germination each treatment}}{\%\ \text{Germination in the control}}$$

2.5 Energy of Germination

It was recorded at the fourth day of germination. Energy of germination was the percentage of germinating seeds at 4 days after sowing relative to the number of seeds tested according to [28].

2.6 Emergence Rate

The emergence rate was computed according to [30] using the following formula:

Emergence rate =1/2 (number of seedling emerged on 5th day after planting+ number of seedling emerged on 8th day after planting).

3. RESULTS AND DISCUSSION

3.1 Storage Periods Effects

The results in (Table 1) showed that final germination percentage, germination index percentage, energy of germination percentage and emergence rate percentage were decreased as storage periods were increased. The results revealed that before storage treatments significantly exceeded the other storage periods in final germination percentage, germination index percentage, energy of germination percentage and emergence rate percentage followed by those storage after 3 months. While, after 12 months from storage recorded lowest final germination percentage, germination index percentage, energy of germination percentage and emergence rate percentage. It could be concluded that increasing storage periods from 3, 6, 9 and 12 months decreased final germination percentage by 3.11, 9.91, 18.87 and 25.80 %, respectively compared with final germination percentage of pre storage treatment. Increasing storage periods from 6, 9 and 12 months decreased germination index percentage by 6.51, 15.34 and 26.40 %, respectively compared with germination index percentage after 3 months. Increasing storage periods from 3, 6, 9 and 12 months decreased energy of germination percentage by 11.06, 15.63, 38.38 and 48.47 %, respectively compared with energy of germination percentage of pre storage treatment. Increasing storage periods from 3, 6, 9 and 12 months decreased emergence rate percentage by 5.73, 11.51, 24.44 and 33.42%, respectively compared with emergence rate percentage of pre storage treatment.

Table 1. Means of germination percentage (%), germination index (%), energy of germination (%) and emergence rate (%) as affected by storage periods, soybean cultivars, storage conditions, package materials and their interactions

Characters Treatments	**Final germination percentage (%)**	**Germination index (%)**	**Energy of germination (%)**	**Emergence rate (%)**
S- Storage periods (months)				
Before storage	94.30	-	87.15	22.83
3 months	91.36	95.07	77.51	21.52
6 months	84.95	88.88	73.52	20.27
9 months	76.50	80.48	53.70	17.25
12 months	69.97	69.97	44.90	15.20
LSD 5%	0.71	0.73	1.23	0.192
V-Soybean cultivars:				
Giza 21	83.40	83.78	62.92	18.87
Giza 22	83.42	81.08	64.71	19.26
Giza 35	83.92	83.72	65.47	19.26
Giza 111	83.30	84.06	72.38	19.92
Crawford	83.03	85.36	71.28	19.76
LSD 5%	NS	0.82	1.23	0.192
C-Storage conditions:				
Ambient conditions	81.40	81.08	63.18	18.63
Refrigerator conditions (10^0C±1)	85.43	86.12	71.53	20.20
F- test	**	**	**	**
P-Package materials:				
Pods in plastic bags	83.38	83.47	68.01	19.46
Pods in cloth bags	83.16	83.37	65.67	19.37
Seed in plastic bags	83.52	83.81	67.29	19.36
Seed in cloth bags	83.61	83.75	68.46	19.47
LSD 5%	NS	NS	1.00	NS
F-test Interactions:				
S×V	**	**	**	**
S×C	**	**	**	**
V×C	NS	NS	**	**
V×C×S	NS	NS	*	*
S×P	NS	NS	**	*
V×P	NS	NS	**	**
S×V×P	**	**	NS	NS
C×P	**	**	**	NS
S×C×P	NS	NS	**	NS
V×C×P	NS	NS	**	**
S×V×C×P	NS	NS	**	NS

*NS=Not significant, *= significant at 5%, **= significant at 1%, LSD= least significant differences.*

In this respect, Arif et al. [9] stated that germination percentage was inversely related to storage duration, where germination gradually decreased from 64.5 to 39.2% as the time in storage increased from 2 to 12 months. In addition, Balesevic- Tubic et al. [31] reported that differences in germination index due to storage periods might be due to lipid changes of seed during storage and decline in phospholipids and polyunsaturated fatty acids leading to marked decline in seed vigor and germination index. Moreover, Mohammadi et al. [32] indicated that seed deterioration results in decreased percentage and rate of germination and decreased percentage of normal seedlings. Seed ageing is generally marked by reduction in vigor [33].The longer seeds storage period increases intensity of seeds ageing [22]. These results are in good agreement with those reported by [8,31,34,35,36,37].

3.2 Storage Cultivars Effects

Results in (Table 1) revealed that Giza 111 cultivar significantly exceeded the others in energy of germination percentage and emergence rate percentage. While, Giza 35 surpassed the others in final germination percentage. Giza 21 cultivar recorded the lowest energy of germination percentage and emergence rate percentage. Giza 22 cultivar recorded the lowest germination index percentage. While, Crawford cultivar recorded the lowest final germination percentage. Giza 111 surpassed Giza 21, Giza 22, Giza 35 and Crawford cultivars in energy of germination percentage by 13.06, 10.59, 9.54 and 1.51 %, respectively. Giza 111 surpassed Giza 21, Giza 22, Giza 35 and Crawford cultivars in emergence rate percentage by 5.27, 3.31, 3.31 and 0.80 %, respectively. Crawford cultivar surpassed Giza 21, Giza 22, Giza 35 and Giza 111 cultivars in germination index percentage by 1.85, 5.01, 1.92 and 1.52 %, respectively. In this respect, Tatic et al. [4] 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. In addition, [38] stated that assessment of some soybean cultivars seed viability during storage by monitoring germination and germination after ageing percentages. Moreover, Doijoide et al. [39] stated that the storability of different soybean cultivars is also regulated by initial seed quality, physical and chemical composition of seed as different cultivars possess different physical structure and chemical composition which determine the viability of seed in storage. These results are in good accordance with those obtained by [4,8,22,31,36,37].

3.3 Storage Conditions Effects

The results showed that a significant effect of storage conditions on the average of final germination percentage, germination index percentage, energy of germination percentage and emergence rate percentage as shown in (Table 1). Storage under refrigerator conditions at 10ºC surpassed ambient conditions in final germination percentage, germination index percentage, energy of germination percentage and emergence rate percentage by 4.71, 5.85, 11.67 and 7.77 %, respectively. In this trend, [9] recorded that highest germination percentages were in seed stored at 4ºC than room temperature. These results are in good harmony with those obtained by [8,31,32,36,37,41].

3.4 Storage Package Materials Effects

The results showed that a significant effect of package materials on the means of energy of germination percentage as shown in (Table 1). The results showed that energy of germination percentage significantly affected by package materials. Highest energy of germination percentage were obtained from storage soybean seed in cloth bags followed by storage seed in plastic bags. However, the lowest energy of germination percentage were obtained from storage soybean pods in cloth or plastic bags. In case of final germination percentage of soybean seed decreases all cases but the rate of deterioration is highest in cloth bag [21]. Seeds were stored in Metallized film bags and Aluminum foil bags observed highly standard germination and seed vigor, and keep water activity and seed moisture content in low level could delay seed quality deterioration followed by Polypropylene bags and woven bag [22].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 [23]. These results are in harmony with those reported by [8,23,34,37].

3.5 Interaction Effects

3.5.1 Interaction between soybean cultivars and storage periods:

The results clearly indicated that pre storage of Giza 35 cultivar recorded the highest final germination percentage followed by storage Giza 111 storage for 3 months (Fig. 1). The lowest final germination percentage was recorded from storage Giza 35 and Giza 111 cultivars after 12 months without significant (at 0.05) differences between them. Highest germination index percentage was produced from storage for 3 months of Giza 111 cultivar. The lowest germination index percentage was recorded from storage Giza 35 and Giza 111 cultivars after 12 months without significant (at 0.05) differences between them (Fig. 2). Highest energy of germination percentage was recorded from pre storage of Giza 111 cultivar followed with Giza 111 cultivar when storage for 3 months. The lowest energy of germination percentage was recorded from storage Giza 21 cultivar after 12 months (Fig. 3). The results clearly indicated that highest emergence rate percentage was obtained from Giza 111 cultivar before storage. While, the lowest emergence rate percentage was recorded from storage Giza 21 and Giza 22 cultivar for 12 months without significant (at 0.05) between them (Fig. 4).These results are in harmony with those reported by [1,8,22,23,34].

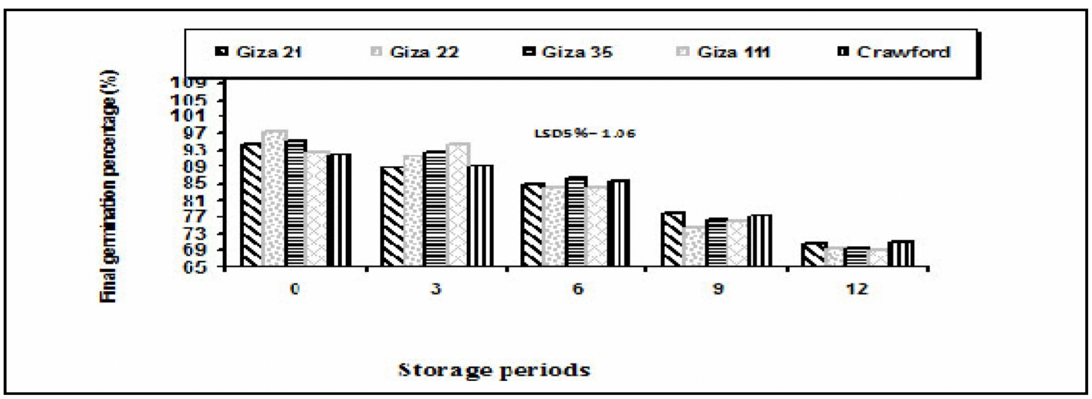

Fig. 1. Averages of final germination percentage as affected by the interaction between soybean cultivars and storage periods

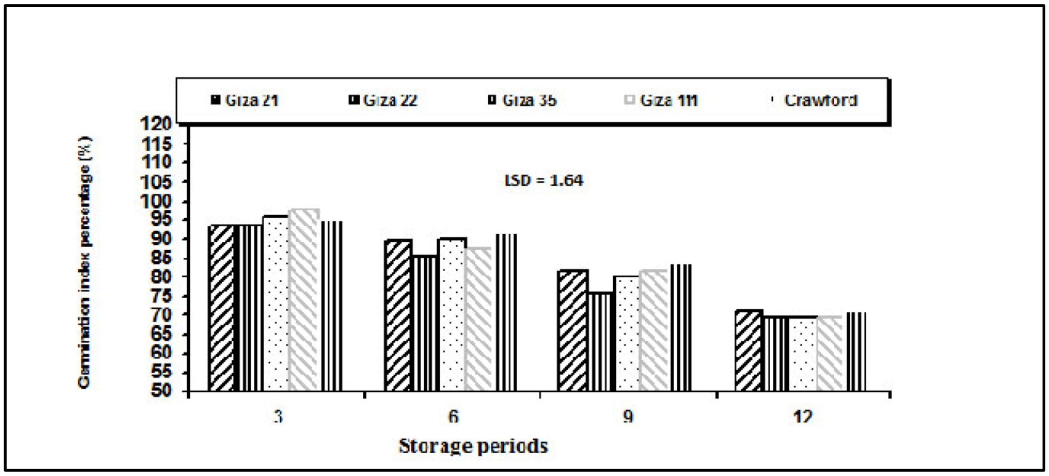

Fig. 2. Averages of germination index percentage as affected by the interaction between storage periods and soybean cultivars

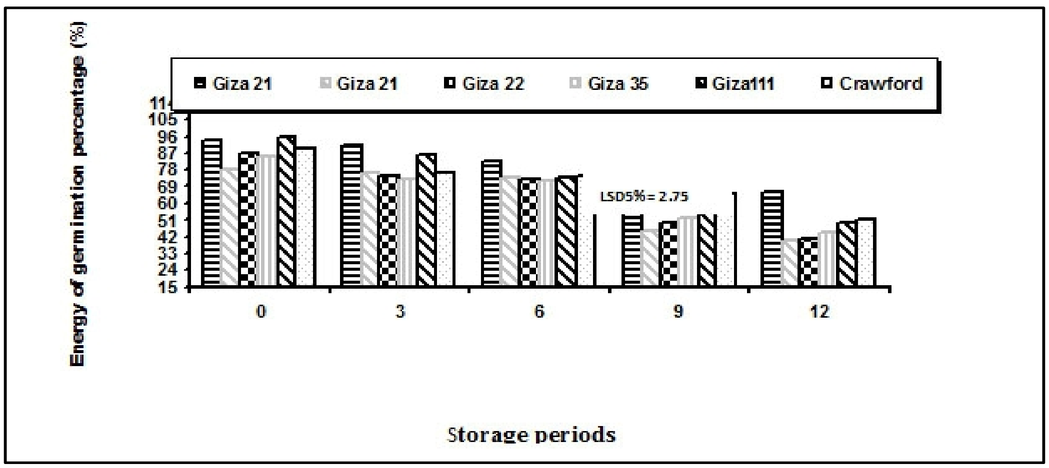

Fig. 3. Averages of energy of germination percentage as affected by the interaction between storage periods and soybean cultivars

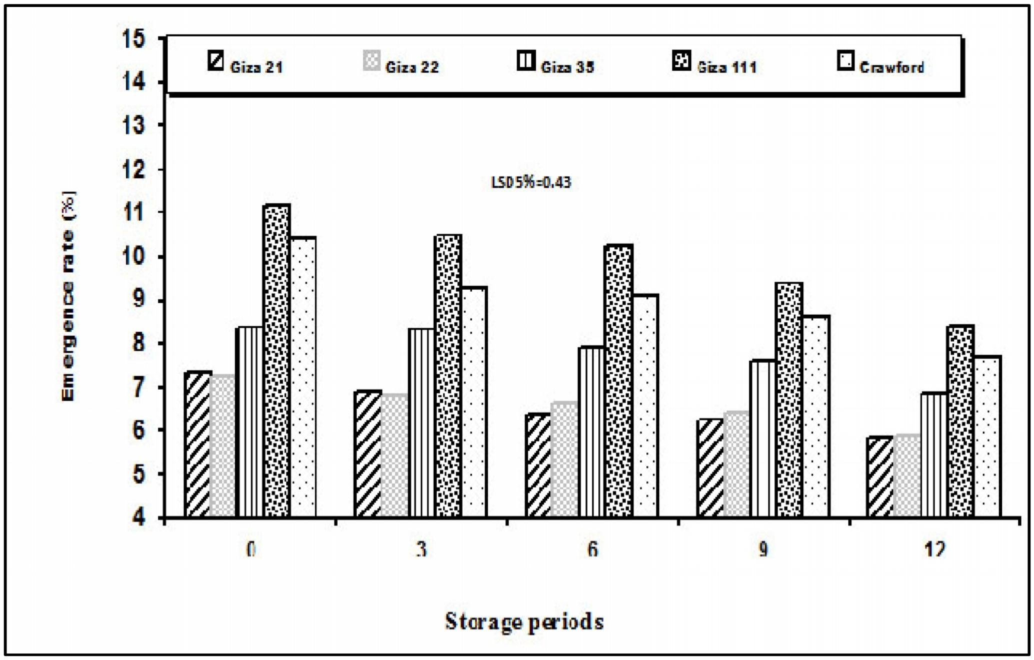

Fig. 4. Averages of emergence rate as affected by the interaction between soybean cultivars and storage periods

3.5.2 Interaction between storage periods and storage conditions effects

The results clearly indicated that pre storage treatment was recorded the highest final germination percentage followed by storage for 3 months under refrigerator conditions at 10ºC (Fig. 5). The lowest final germination percentage was recorded from storage for 12 months of storage under ambient conditions. The results clearly showed that after 3 months of storage treatment under refrigerator conditions at 10ºC recorded highest germination index percentage followed by storage after 6 months under refrigerator conditions at 10ºC (Fig. 6). The lowest germination index percentage was recorded from storage for 12 months under ambient conditions. The results clearly showed that pre storage treatment recorded highest energy of germination percentage followed by storage for 3 months under refrigerator conditions at 10ºC (Fig. 7). The lowest energy of germination percentage was recorded for 12 months of storage under ambient conditions. The results clearly indicated that pre storage treatment recorded the highest emergence rate percentage followed by storage for 3 months under refrigerator conditions at 10ºC (Fig. 8). The lowest emergence rate percentage was recorded from for 12 months under ambient conditions. These results are in conformity with those reported by [8,31,32,36,37,41].

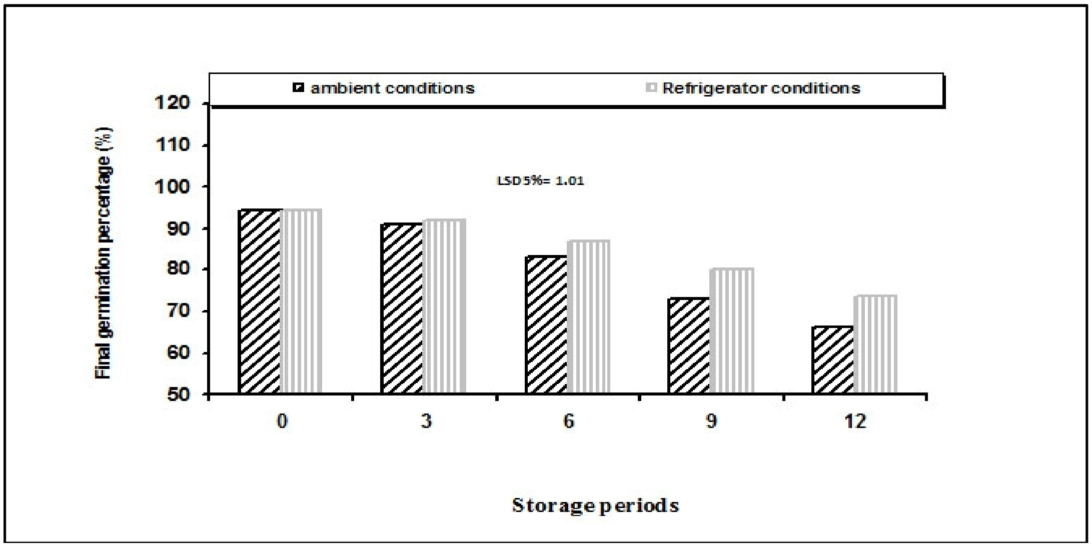

Fig. 5. Averages of final germination percentage as affected by the interaction between storage conditions and storage periods

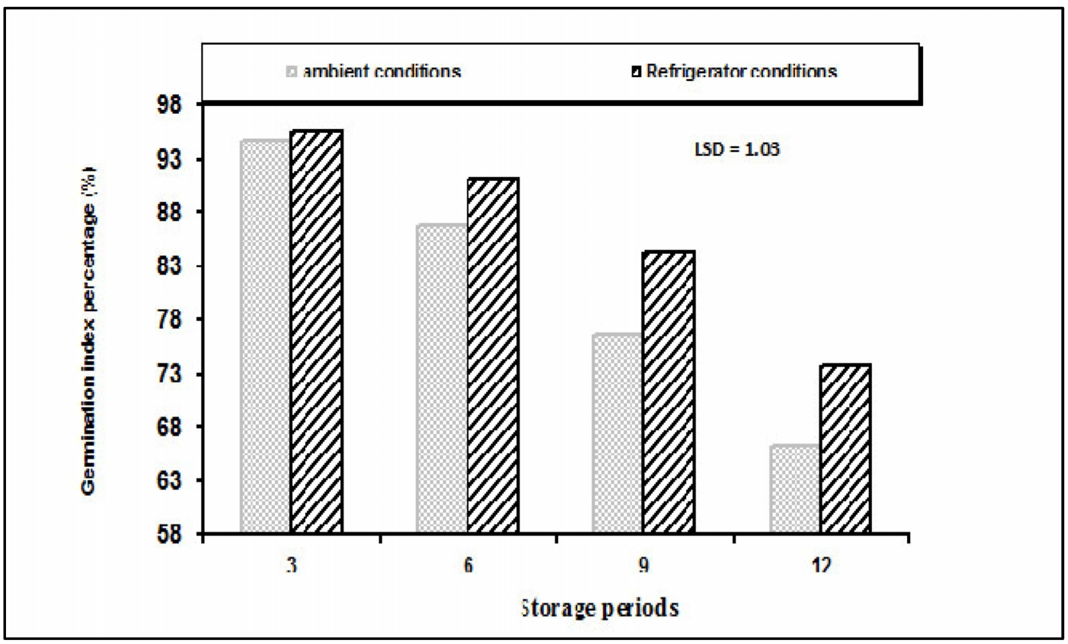

Fig. 6. Averages of germination index percentage as affected by the interaction between storage conditions and storage periods

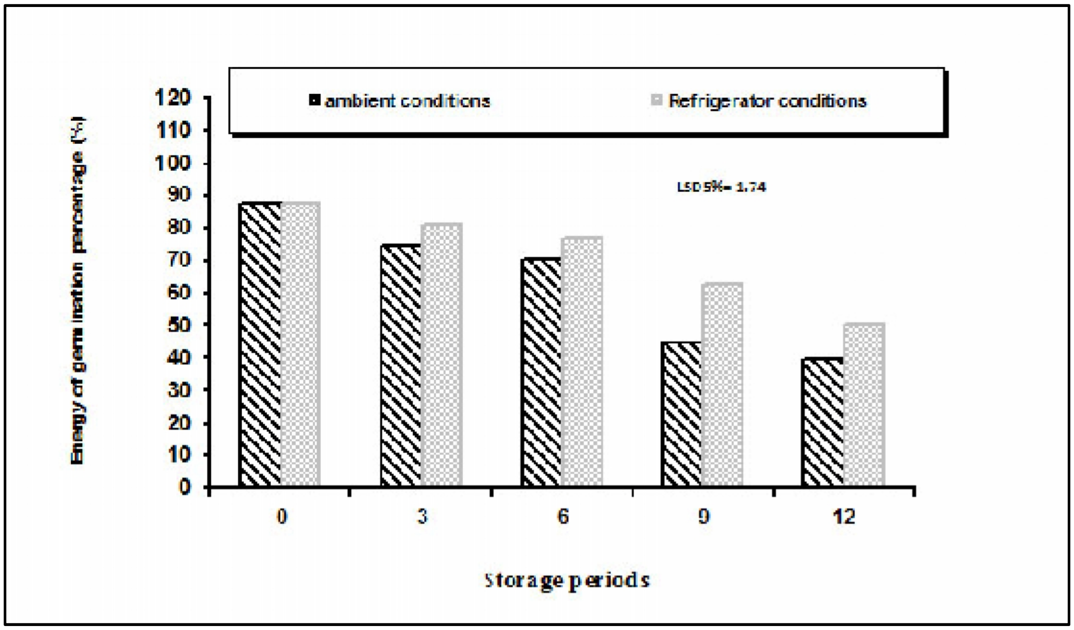

Fig. 7. Averages of energy of germination percentage as affected by the interaction between storage periods and storage conditions

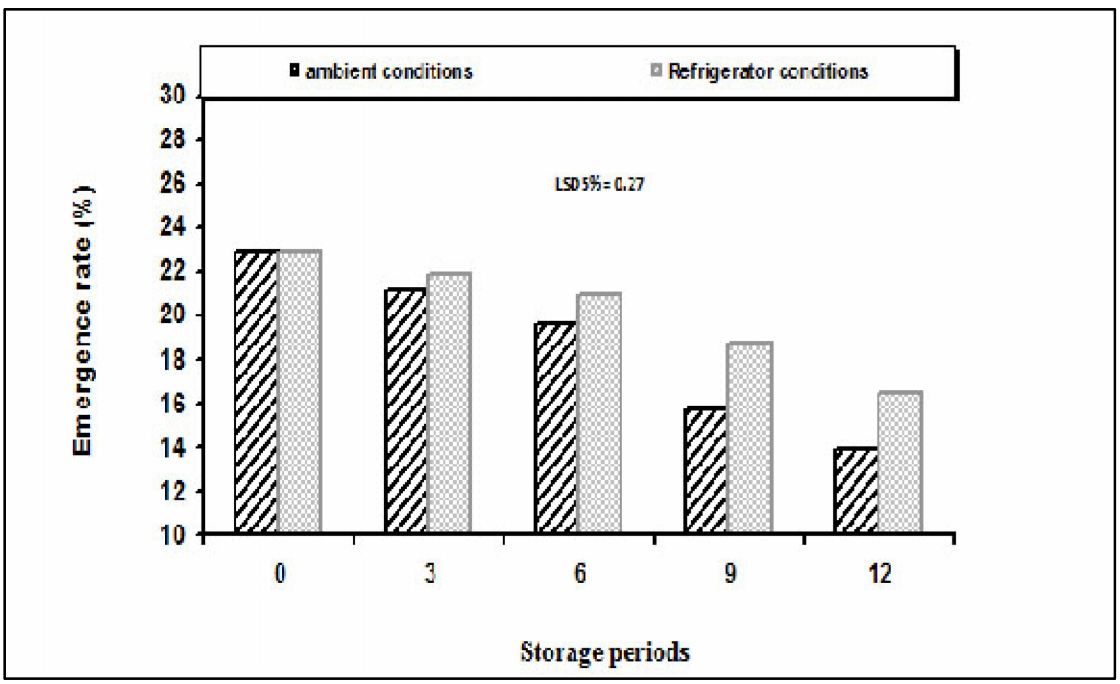

Fig. 8. Averages of emergence rate as affected by the interaction between storage conditions and storage periods

3.5.3 Interaction between soybean cultivars and storage conditions effects

The results clearly indicated that highest energy of germination percentage was obtained from storage Giza 35 and Giza 111 cultivars under refrigerator conditions (10 ± 1ºC). The lowest energy of germination percentage was obtained from storage Giza 21 and Giza 22 cultivar under ambient conditions without significant (at 0.05) differences between them (Fig. 9). Highest emergence rate percentage was obtained from Crawford followed by Giza 111 cultivars when storage under refrigerator conditions (10 ± 1ºC). The lowest emergence rate percentage was obtained from storage Giza 21 and Giza 22 cultivars under ambient conditions without significant (at 0.05) differences between them (Fig. 10).These results are in conformity with those reported by [1,8,22,23,34,40].

3.5.4 Interaction between storage periods, soybean cultivars and storage conditions

The results clearly indicated that highest energy of germination percentage was obtained from before storage of Giza 22 cultivar. The lowest energy of germination percentage was obtained from storage Giza 21 under ambient and or refrigerator conditions for 12 months without significant (at 0.05) differences between them (Fig. 11). Highest emergence rate percentage was obtained from before storage of Giza 22 cultivar. The lowest emergence rate percentage was obtained from storage Giza 22 cultivar under ambient and refrigerator conditions for 12 months without significant (at 0.05) differences between them (Fig. 12).These results are in good agreement with those reported by [8,31,32,36,37,41].

3.5.5 Interaction between storage periods and package materials

The results clearly indicated that energy of germination percentage and emergence rate percentage significantly affected due to the interaction between storage periods and package materials. It could be noticed that highest energy of germination percentage was obtained from pre storage treatment followed by storage soybean cultivars seeds in cloth bags for 3 months (Fig. 13). The lowest energy of germination percentage was obtained from storage soybean pods in cloth bags for 12 months. The results showed that highest emergence rate percentage was obtained from pre storage treatment followed by storage of studied soybean cultivars seeds in cloth bags for 3 months (Fig. 14). The lowest emergence rate percentage was obtained from storage soybean pods in cloth bags for 12 months. These results are conformity with those reported by [8,40].

3.5.6 Interaction between soybean cultivars and package materials

The results clearly showed that highest energy of germination percentage were produced from storage Giza 111 cultivar seeds in cloth bags (Fig. 15). The lowest energy of germination percentage were obtained from storage Giza 21 cultivar pods in cloth bags or seeds in plastic bags without significant (at 0.05) differences between them. Highest emergence rate percentage were produced from storage Giza 111 cultivar pods storage in plastic bags or seeds in cloth bags (Fig. 16).The lowest emergence rate percentage were obtained from storage Giza 21 cultivar pods in cloth bags or seeds in plastic bags without significant (at 0.05) differences between them. These results are conformity of those reported by [8,31,32,36,37].

3.5.7 Interaction between storage periods, soybean cultivars and package materials

The results clearly indicated that highest final germination percentage was obtained from before storage of Giza 22 cultivar. The lowest energy of germination percentage was obtained from storage Giza 35 cultivar pods in plastic bags for 12 months (Fig. 17). Highest germination index percentage was obtained from Giza 35 cultivar before storage. The lowest germination index percentage was obtained from storage Giza 35 cultivar pods in plastic bags for 12 months (Fig. 18).These results are in good agreement with those reported by [8,31,32,36,37,41].

3.5.8 Interaction between storage conditions and package materials

The results clearly showed that highest final germination percentage was obtained from storage soybean cultivars pods in plastic bags under refrigerator conditions (10 ± 1ºC). The lowest final germination percentage was obtained from storage soybean cultivars pods in cloth bags under ambient conditions (Fig. 19). Highest germination index percentage was obtained from storage soybean cultivars pods in plastic bags under refrigerator conditions (10 ± 1ºC). The lowest germination index percentage was obtained from storage soybean cultivars pods in plastic bags under ambient conditions (Fig. 20). Highest energy of germination percentage was obtained from storage soybean cultivars seeds in cloth bags under refrigerator conditions (10 ± 1ºC). The lowest energy of germination percentage was obtained from storage soybean cultivars seeds in plastic bags under ambient conditions (Fig. 21). These results are in good agreement with those reported by [8,31,32,36,37].

3.5.9 Interaction between storage periods, storage conditions and package materials

The results clearly indicated that highest energy of germination percentage was obtained from pre storage treatment followed by storage soybean seed cultivars in cloth bags under refrigerator conditions (10 ± 1ºC) for 3 months. The lowest energy of germination percentage was obtained from storage soybean seeds cultivars in plastic bags under ambient conditions (Fig. 22). These findings are in good conformity with those reported by [8,31,32,36,37].

3.5.10 Interaction between soybean cultivars, storage conditions and package materials

The results clearly indicated that highest energy of germination parentage was obtained from storage Giza 111 cultivar under refrigerator conditions (10 ± 1ºC) as seeds in cloth bags (Fig. 23). Lowest energy of germination parentage was obtained from storage Giza 35 cultivar under ambient condition seeds in plastic bags. The results clearly indicated that highest emergence rate percentage was obtained from storage Giza 111 cultivar under refrigerator conditions (10 ± 1ºC) using seeds in plastic bags (Fig. 24). Lowest emergence rate percentage was obtained from storage Giza 21 cultivar under ambient condition using seeds in plastic bags. These results are in good agreement with those reported by [8,31,32,36,37].

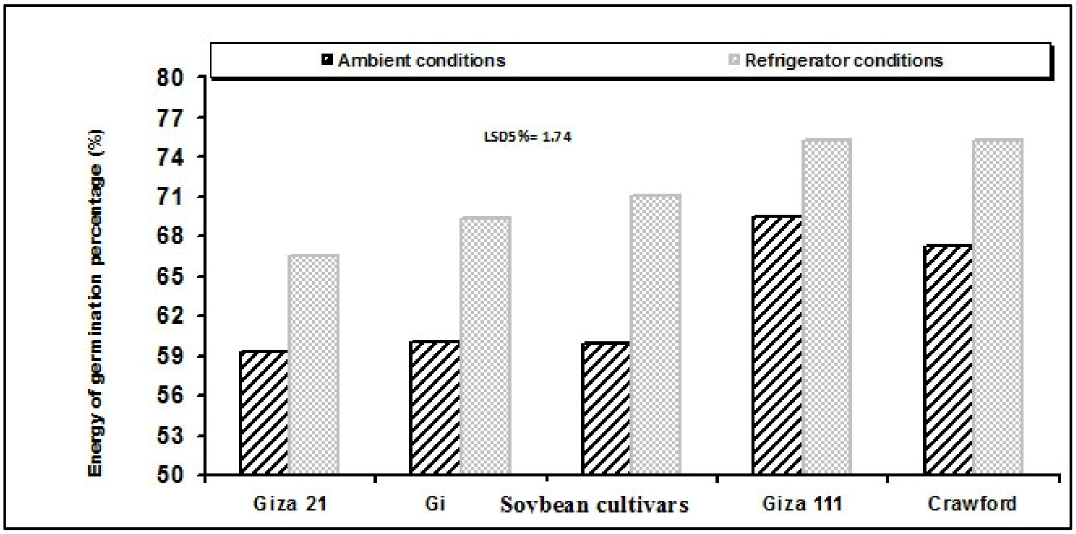

Fig. 9. Averages of energy of germination percentage as affected by the interaction between soybean cultivars and storage conditions

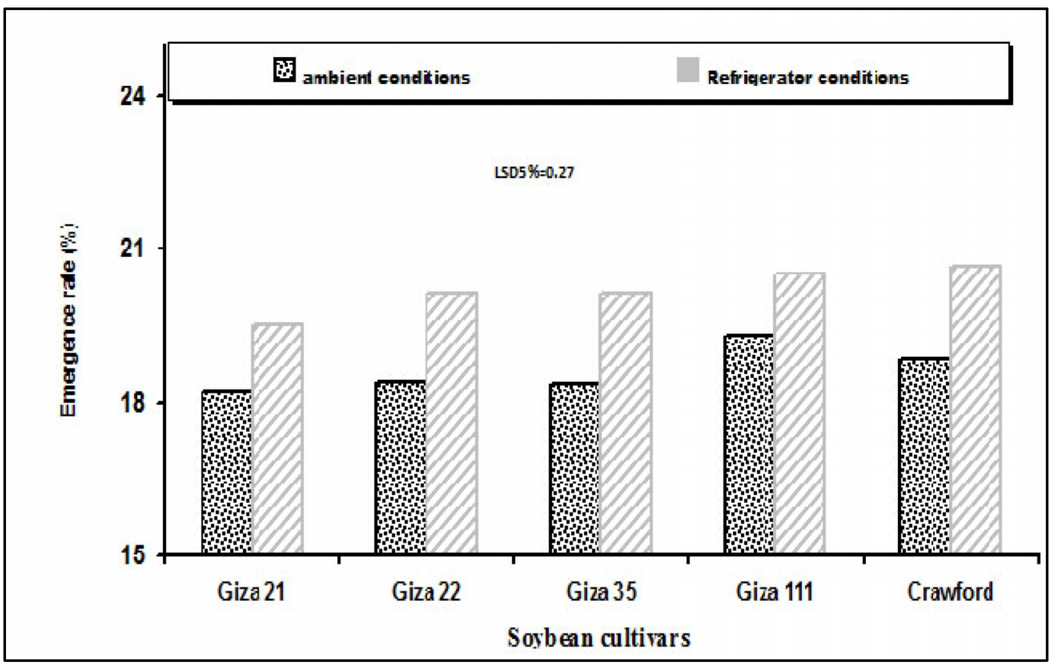

Fig. 10. Averages of emergence rate as affected by the interaction between soybean cultivars and storage conditions

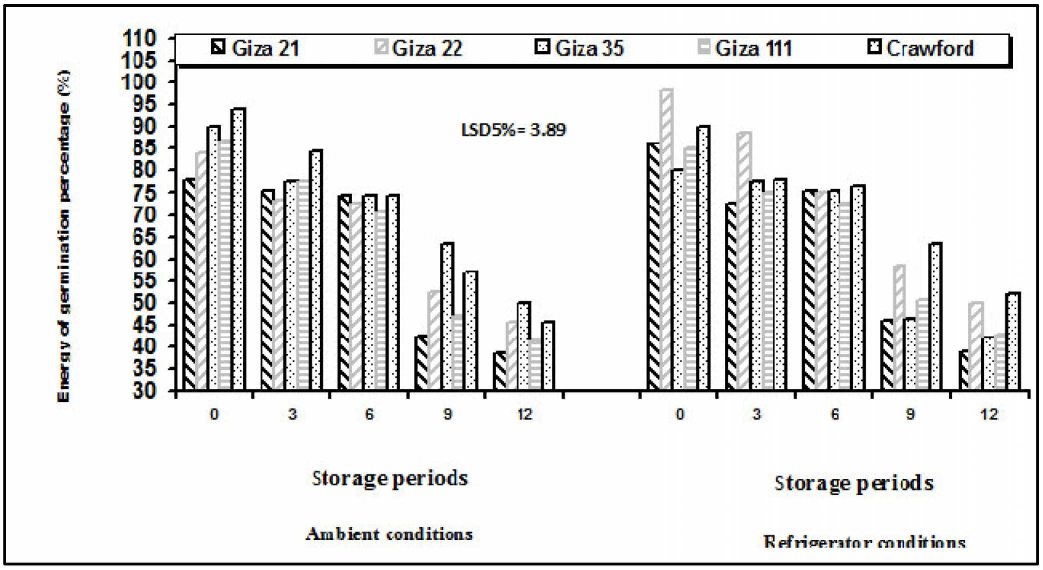

Fig. 11. Averages energy of germination as affected by the interaction between storage periods, soybean cultivars and storage conditions

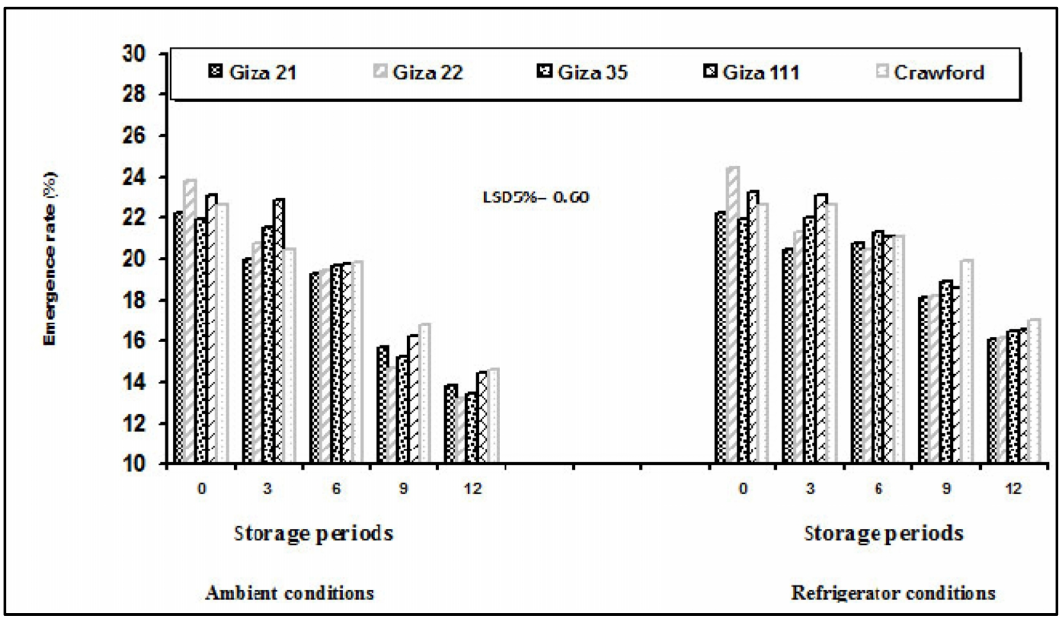

Fig. 12. Averages of emergence rate as affected by the interaction between storage periods, soybean cultivars and storage conditions

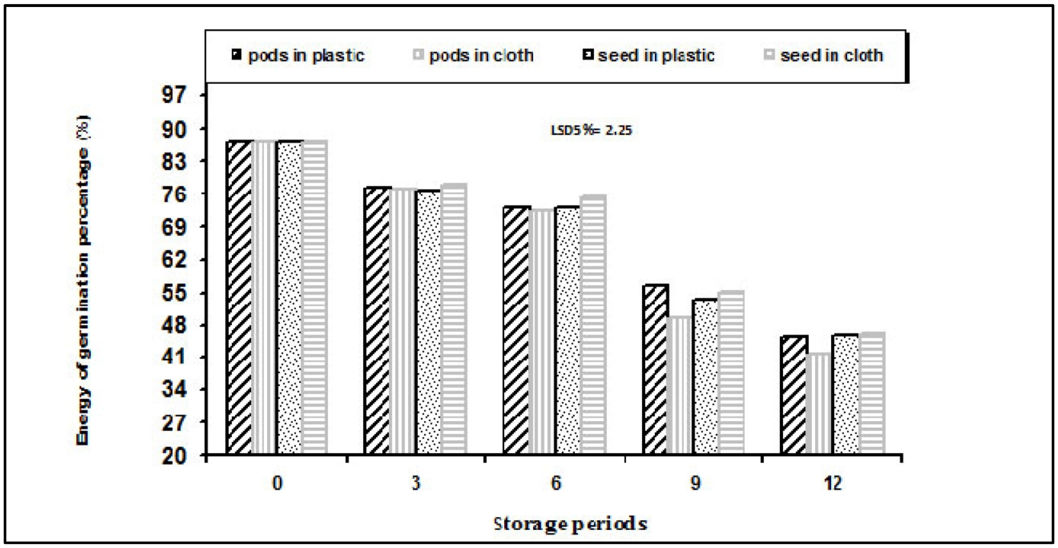

Fig. 13. Averages of energy of germination percentage as affected by the interaction between storage periods and package materials

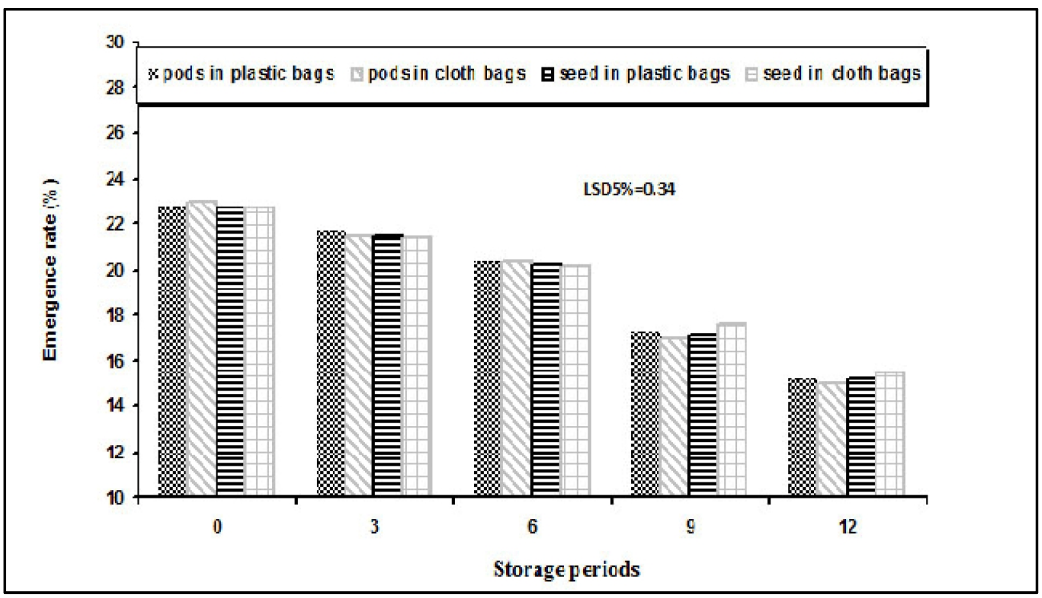

Fig. 14. Averages of emergence rate as affected by the interaction between storage periods and package materials

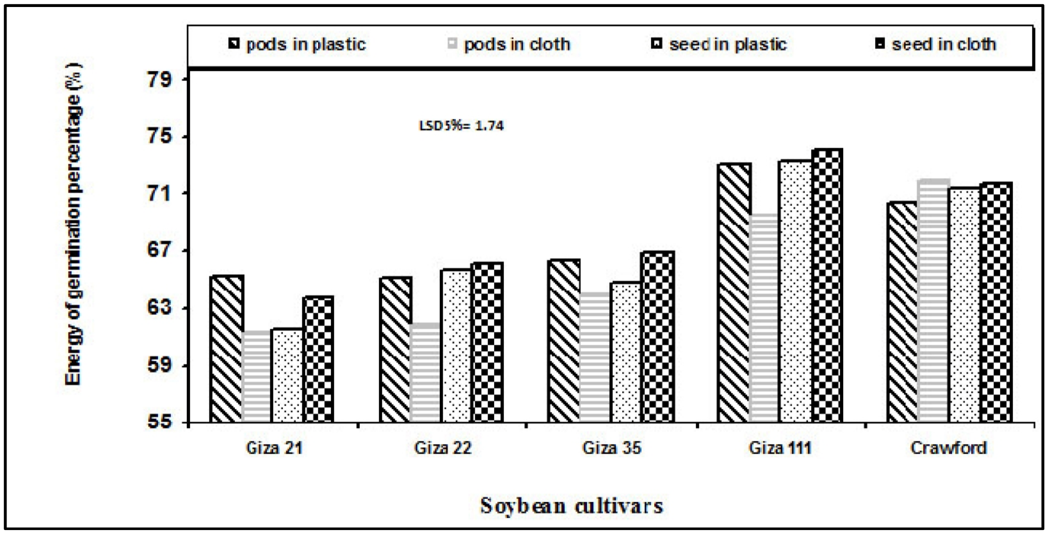

Fig. 15. Averages of energy of germination percentage as affected by the interaction between soybean cultivars and package materials

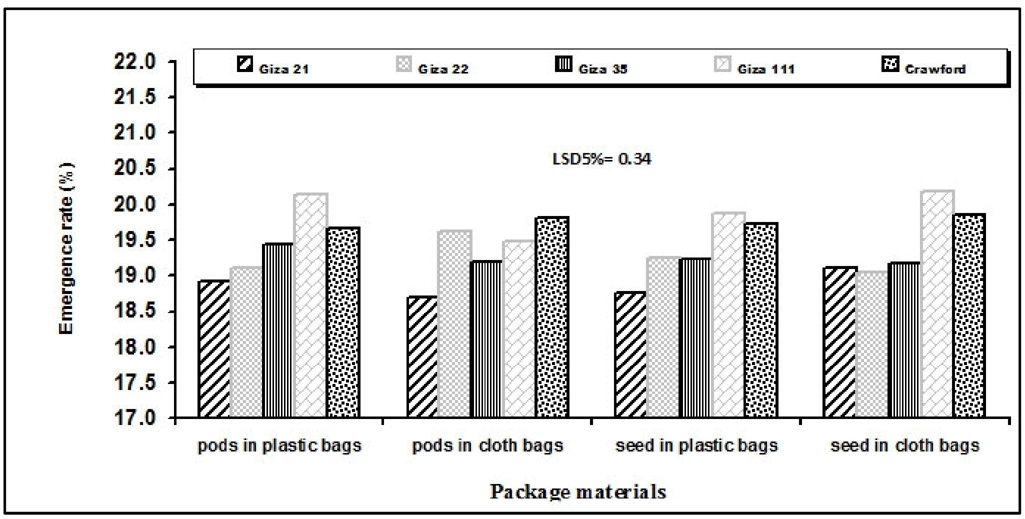

Fig. 16. Averages of emergence rate as affected by the interaction between soybean cultivars and package materials

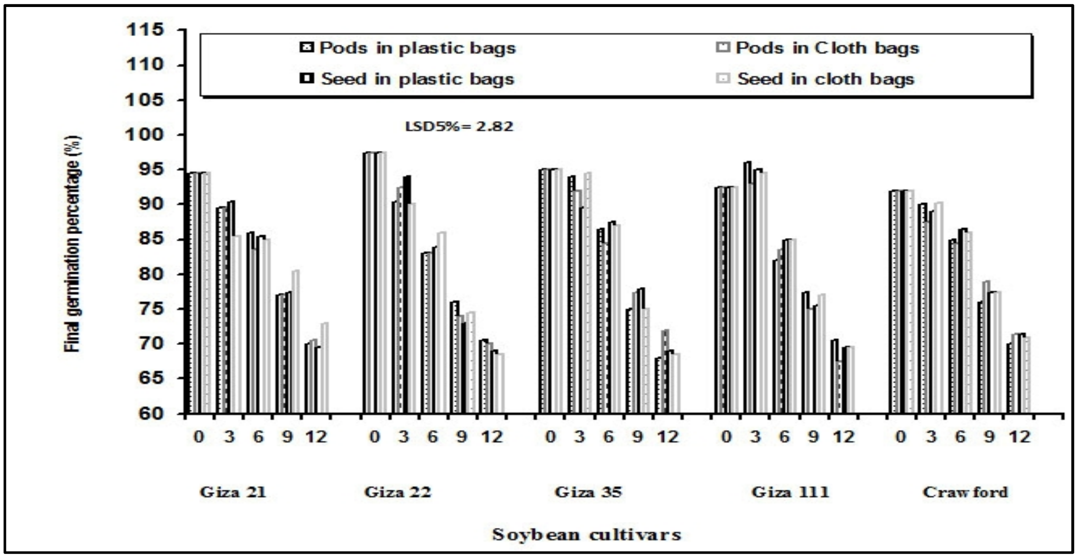

Fig. 17. Averages of final germination percentage as affected by the interaction between soybean cultivars, package materials and storage periods

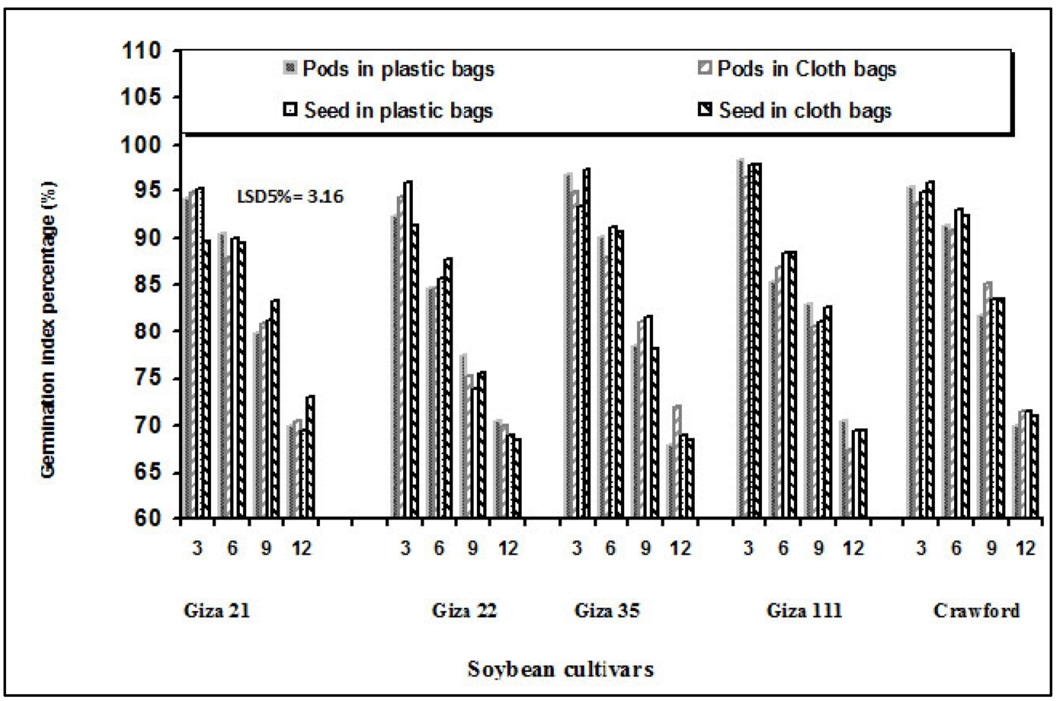

Fig. 18. Average of germination index percentage as affected by the interaction between soybean cultivars, package materials and storage

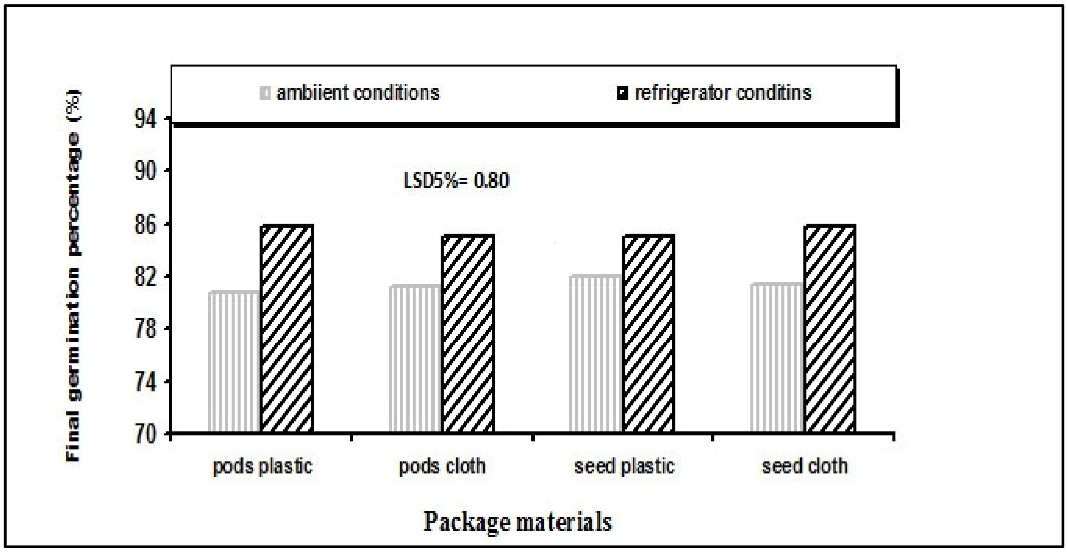

Fig. 19. Averages of final germination percentage as affected by the interaction between storage conditions and storage periods

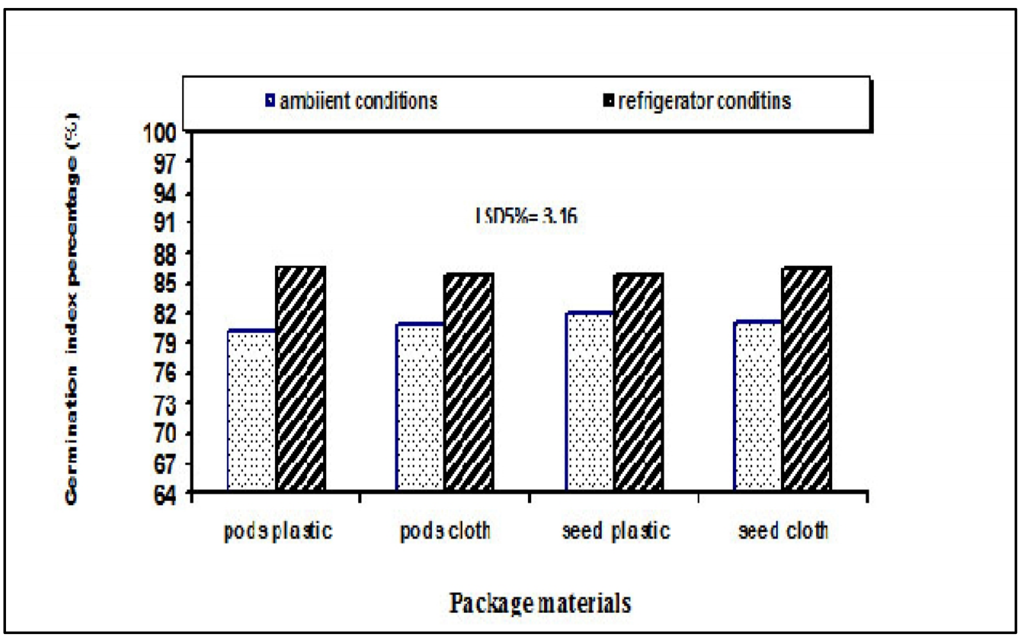

Fig. 20. Averages of germination index percentage as affected by the interaction between storage conditions and package materials

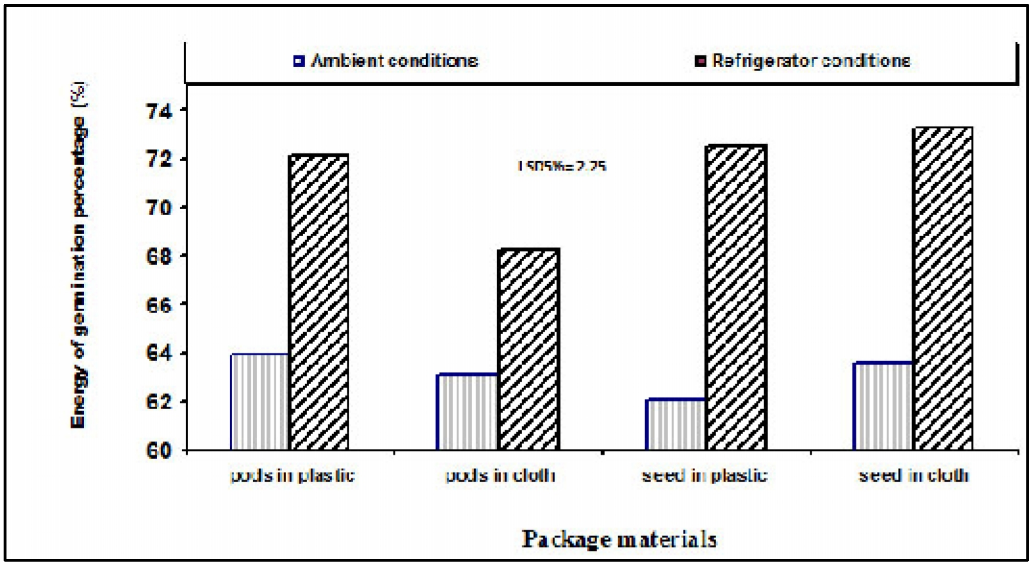

Fig. 21. Averages of energy of germination percentage as affected by the interaction between storage conditions and package materials

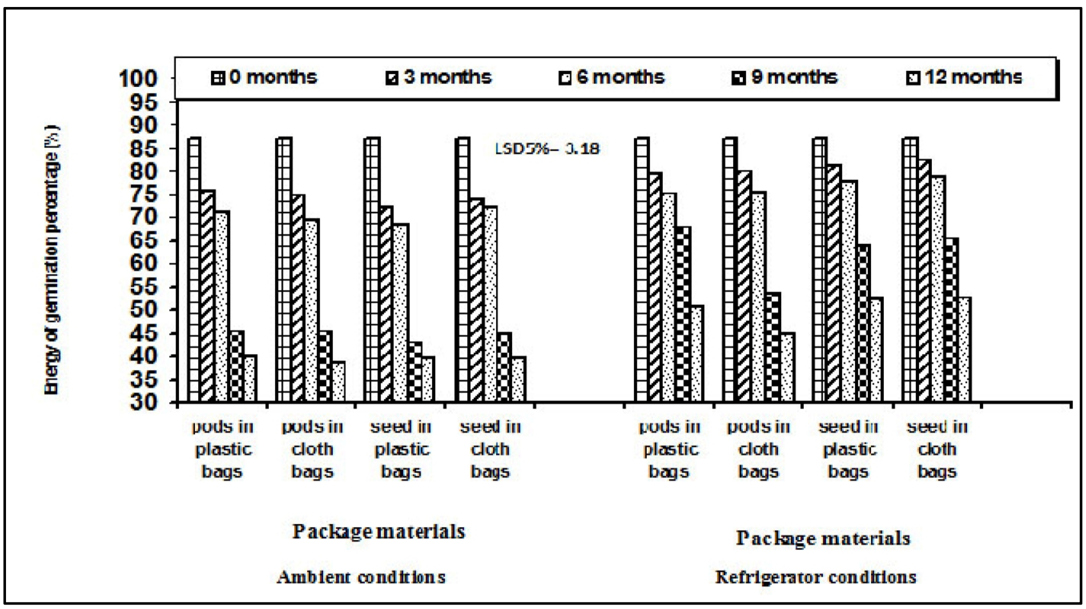

Fig. 22. Averages of energy of germination as affected by the interaction between storage periods, storage conditions and package materials

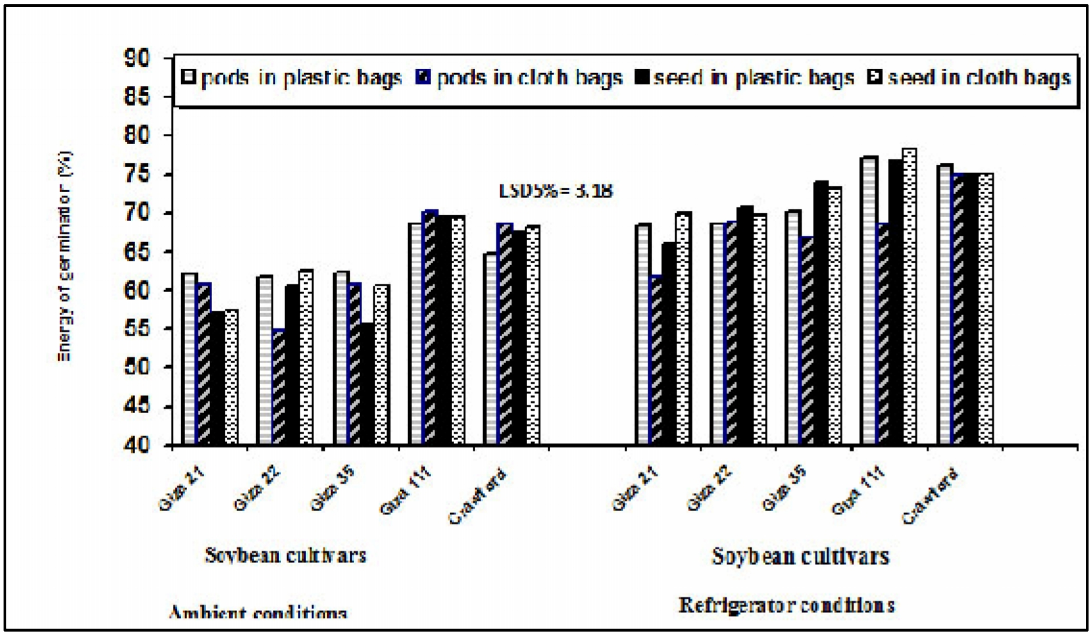

Fig. 23. Average of energy of germination as affected by the interaction between soybean cultivars, storage conditions and package materials

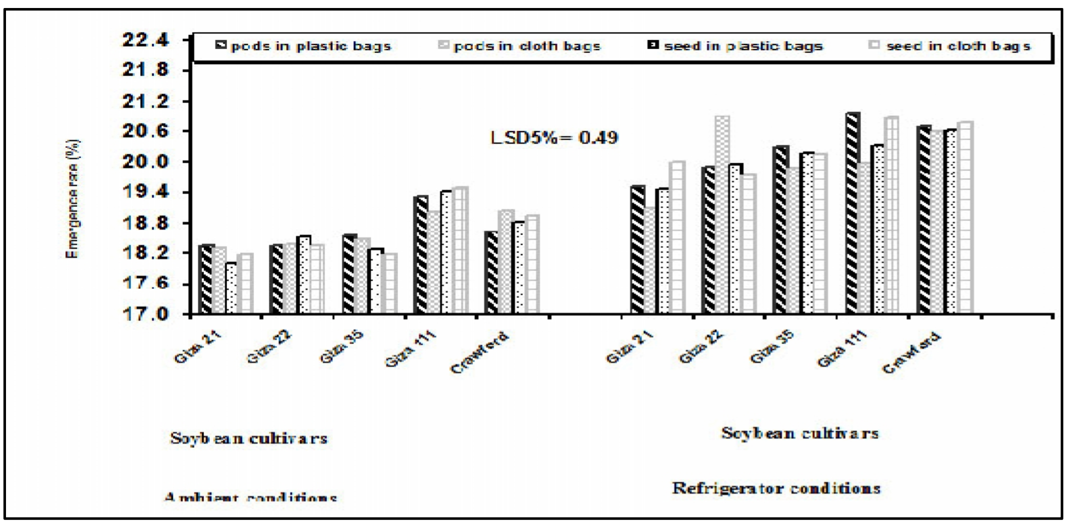

Fig. 24. Averages of emergence rate as affected by the interaction between soybean cultivars, storage conditions and package materials

4. CONCLUSION

This investigation was revealed that for maximizing soybean seed germination parameters, it should be storage Giza 111 cultivar under refrigerator conditions (10 ± 1ºC) as pods or seeds with cloth bags for 3 months.

ACKNOWLEGMENTS

Mr. M. S. Sheteiwy wishes to express his most sincere and gratitude to Prof. Dr. Ahmed A. Kandil and Prof. Dr. Ali E. Sharief, Agronomy Dep., Faculty of Agriculture, Mansoura University, for possible help and extraordinary effort during the achievement of this investigation. Their guidance and encouragement during the extraordinary effort during writing this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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