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Physiological studies on the stored seeds for some crops

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ABSTRACT

There is no doubt that the viability of the seeds (the vigour and ability of the seeds to germinate) is one of the necessary factors to obtain a plant density of high production crops. The viability of the seeds may be adversely affected during storage by environmental factors, causing the loss of the viability of these seeds. Therefore, loss of seed viability is one of the problems facing agricultural production that has received increasing research attention due to the fact that the information on the causes of loss of seed viability is not yet complete. Thus, this research aimed at studying the physiological changes during the early germination stage in the seeds stored for some crops under the uncontrolled environmental conditions (heat and moisture; open storage), in an attempt to identify the physiological changes associated with the loss of seed viability during storage. To achieve this, the seeds of wheat-barley- pearl millet-corn-broad bean were used, which were harvested in different seasons (2017, 2018), as the seeds stored for a period of two and one of years, respectively under ambient conditions. 2019 season seeds, they were used as non-stored seeds for comparison (control). **The results obtained can be summarized as follows:**

(A) - Seed viability indices. It was noticed that storing crop seeds used in the study for several different years had a significant effect on seed germination and resulted in a delay in root emergence (germination index) and a decrease in the germination capacity at a decreasing rate with an increase in the length of storage period for all seeds used in the study. It was found that the indicators of seed quality and vigour decreased with increasing storage time for all seeds used in the research.

(B)- Seedling growth indices. The results of the fresh and dry weight of both the epicotyl and the root (at the end of the germination period/120 hours) showed an inverse proportion to the length of storage period for all seeds used in the research. Seed storage led to a significant decrease in the percentage of dry weight loss of germinated seeds (remnants of germinated seeds at the end of the germination period) at a decreasing rate with increasing storage period. Storage of seeds for several different years resulted in a significant decrease in the length of both the epicotyl and the root (during and at the end of the germination period respectively) at a decreasing rate with the increase in the storage period. It was also noted that the length of the root was affected to a greater degree relative to the length of the epicotyl.

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(C)- Water uptake and solutes leakage. The stored seeds showed a significant decrease in water uptake, as this diminishing effect increased and was evident by increasing the storage time. It was found that the degree of electrical conductivity (EC) of the leaked solutes from the seeds is inversely proportional to the vitality of the seeds, as the low vital seeds gave a high electrical conductivity degree and *vice versa*, and this was observed in all the seeds used in the study.
The increased quantities of leakage with increasing seed life indicate the occurrence of membrane damage that limits the leakage of these solutes from the tissues and thus this leakage leads to weak seedling growth to deplete the metabolites necessary for growth and leakage out of the seeds. *Finally*, it is recommended to continue research with regard to chemical changes related to loss of seed viability during open storage, which we could not closely study through this research, due to the role that these changes may play in causing deterioration of seeds during storage and with knowledge of such changes and with the above. Access to it from physiological changes can, therefore, reach the best way to preserve the viability of the seeds as long as possible.

KEYWORDS :

Seed, viability, germination, storage, physiological changes.

1. INTRODUCTION

There is no doubt that the vitality of seeds is one of the necessary factors to obtain a high plant density for crop production, but we find that seeds, like any other organism, cannot maintain their vitality on a continuous basis and thus deteriorate and die. It has been found that this deterioration in the seeds is adversely affected to a great extent during seed storage by the prevailing environmental factors at the time of storage, especially the temperature and relative humidity in the atmosphere of the store, as well as the moisture of the stored seeds. These factors work together with other factors (which does not expand here to mention it) to reduce the span of seed germination% in the field and a slow growth of the seedlings resulting from such seeds with an increase in their susceptibility to disease or to environmental factors prevailing in the field, which is reflected in its significant impact on the resulting crop (in terms of quantity and quality) (Al-Haddad et al. , 1995). Hence, we find that the survival time of seeds in a live form as long as possible is one of the important things that is taken into account when preparing programs related to the development, reproduction, storage and distribution of seeds for agriculture or other purposes (Simarski 1986). Therefore, the viability of seeds during storage is one of the problems facing agricultural production that has received increasing research attention. However, the information on the reasons leading to loss of seed viability during storage is still not fully detailed yet (Al-Fakhry & Khalaf, 1983). Accordingly, it is necessary to understand this process (loss of seed viability) in order to provide appropriate conditions that in turn reduce the occurrence of deterioration in seed viability during storage or at least the safe storage conditions for seeds. In a study conducted by Anderson (1970) on grains of one of the types of barley (*Hordeum vulgare* L.), observed slight differences (0-6%) in the germination rate of grains as well as the average embryonic axis length (mesocotyl) in the case of seedlings produced from grains. Gody et al. (1974) showed that the germination rate of soybean seeds and also the seedling growth strength of seeds obtained from seeds stored at 25°C and 85% relative humidity decreased continuously with increasing seed storage period. Thiesen et al. (1977) demonstrated in their experiments with the grains of a stored barley species, the dry weight loss of stored seeds was largely dependent on the temperature, reaching 0.5% in the case of grains that were stored at a temperature of 5-15°C for 9 months, but when storing the grains either at 15-30°C for 9 months or at a temperature of 20-45ºC for a period of 3 months, the percentage of dry weight loss reached 1%. EL-Bagoury et al. (1980) conducted a study on the seeds of some cultivars of soybean (cvs. Clark and Boiasser) in terms of their response to conditions and storage period (10 or 25ºC for a period of 1-12 months). The fresh or dry weight of the seedlings produced from the seeds, were significantly reduced by increasing both temperature and storage period. Ghosh et al. (1981) indicated that the germination rate of grains of one of the types of rice (*Oryza sativa* L.) and the seedling growth force obtained from it (root and epicotyl length) gradually decreased with increasing grains storage period at 28°C. Alizaga et al. (1987) reported that the percentage of soybean seed germination and the length of the epicotyl of the developing seedlings were significantly reduced when the seeds were stored at 16% moisture content at 30ºC. Rocha (1989) found that the germination velocity and growth vigor of seedlings produced from soybean seeds with a moisture content of 12% and stored at a temperature of 26°C and 80% relative humidity, duration of 18 months, both decreased with increasing seed storage time. Ferguson et al. (1990) studied the effect of storage conditions on germination and growth strength of soybean seed seedlings, and found through their study that there was a significant decrease in these traits after storing seeds for 10 months at a temperature of 25°C and seed moisture content of 11.5%. Arulnandhy and Senanavake (1991) showed that there is a sharp decline in the viability of soybean seeds (germination percentage and seedling growth strength) stored at 16–38°C and 73.2% RH for 9 months. Nath et al. (1991) found that storing the grain of one of the wheat species (*Triticum aestivum* L.) at a temperature of 40°C and a relative humidity of 100% resulted in an apparent decrease in the viability of the grains (germination rate and seedling growth strength). Bharat et al. (1993) indicated that the germination rate of soybean seeds stored at 16-35°C and 40-85% RH for 10 months was lower (48%) than in the case of non-stored seeds

(84%). Hallion (1975) stated that the concentration of both sodium (Na) and potassium (K) in the soaked water of stored cotton seeds was increased by increasing the seed storage time. Parrish and Leopold (1978) showed that storing soybean seeds at 40°C and 100% RH resulted in increased solubility from the seeds when soaked in water for 6 hours, with a dry weight loss of 10% and a decrease in the water absorption rate of the seeds. Ray and Gupta (1979) indicated that the degree of electrical conductivity is (EC) for the water in which the rice grains were soaked, as well as the total nitrogen and reducing sugars concentration, was increased by increasing the storage time of these seeds up to 18 months at 30°C. Leopold (1980) showed that degraded soybean seeds when soaked in water, the concentration of soluble leaks from these seeds was 5 times higher than that of live seeds. Rocha (1989) reported that soybean seeds with a moisture content of 12, 10, 8, 6% and stored at a temperature of 26ºC and 80% relative humidity for 18 months when soaked in water, the rate at which they absorbed water was much lower than that of the unstored counterpart. Whereas, the EC value and the concentration of reducing sugars were higher than in the case of unstored seeds. Vyas et al. (1990) studied the relationship between germination rate of stored soybean seeds (for 18 months at 30°C and 80% relative humidity) and the rate of soluble excretion from these seeds, and found that there is an apparent decrease in the germination% of soybean seeds stored under the previous conditions and with the correlation of this deficiency with an increase in the concentration of soluble escapes from these seeds compared to their non-stored counterpart. **Thus,** this research aimed at studying the physiological changes that occur during the early stages of the germination process for several types of seeds (or grains stored for several different crop years, as an attempt to find out some of the physiological changes associated with the occurrence of a loss in seed viability during storage. Seeds and grains that are not stored and stored for different periods of time have been used for some crops of high economic importance, which are grown in large areas in the Sebha area, in addition to the continuous increase in the need for them at the present time, which calls for storing the surplus from then on its use in different aspects of life, especially in the field of production. The crops whose seeds (or grains) were used are: wheat-barley-corn–pearl millet–broad bean.

2. MATERIALS AND METHODS

The study was conducted in the laboratories of the Department of Botany, Faculty of Science, Sebha University, Libya during the period of 10-27/11/2019-as follows:

Plant materials.

In this research, five types of seeds (or grains) belonging to five different crops were used, namely: barley – pearl millet - wheat - corn - broad bean (Table 1) shows an definition of the crops to which the seeds used in the study. These seeds were obtained from the Agricultural Research Center in Sebha for 2017, 2018 and 2019 seasons. The seeds of

2017 and 2018 were stored two or one year, respectively by the center in sacks of Jute under ambient conditions (open storage, was that is, without control of temperature and humidity (limited only to the temperature and relative humidity prevailing in the Sabha area during the storage period), i.e., in summer, temperature was 40-45^{o}C and relative humiditity (RH%) was 17-25 %, while in winter, temperature was 17-28^{o}C and RH% was 53-34. The seeds of 2019 season were used as a control i.e., non-stored seeds. The seeds of the three seasons were obtained from the center in the fall of 2019 season. The seeds shown in Table (2), taking into account that the seed storage period is represented by the crop years used in the study. Notably, the agricultural definition of seeds

Table 1. The identification of used crops in the study

Crop	Local name	Studied local cv.	Family name	Scientific name
Barley	Alshyair	Riyhan	Poaceae (Graminae)	*Hordeum vulgare* L.
Pearl millet	Albashnah	-	Poaceae (Graminae)	*Pennisetum glaucum* L.
Wheat	Alkamh	Al- Khorysy	Poaceae (Graminae)	*Triticum aestivum* L.
Maize (corn)	Alsybool	-	Poaceae (Graminae)	*Zea mays* L
Broad bean (Horse bean)	AlFoul Albalady	-	Fabaceae (Leguminosae)	*Vicia faba* L.

Table 2. Crop years, area of seed acquisition, location and nature of the torage

Crop	Area of seed acquisition	Crop year	The location and nature of the storage
Barley	Sabha	٢٠١٧، ٢٠١٨، ٢٠١٩	Sebha Agricultural Research Center - jute bags
Pearl millet	Sebhah	٢٠١٧، ٢٠١٨، ٢٠١٩	Sebha Agricultural Research Center – jute bags
Wheat	Sebha	٢٠١٧، ٢٠١٨، ٢٠١٩	Sebha Agricultural Research Center – jute bags
Maize (corn)	Sebha	٢٠١٧، ٢٠١٨، ٢٠١٩	Sebha Agricultural Research Center – jute bags
Broad bean (Horse bean)	Sebha	٢٠١٧، ٢٠١٨، ٢٠١٩	Sebha Agricultural Research Center – jute bags

will be used in the writing of the research and limited to it as the plant part used in the reproduction of sexual plants in order to avoid the intervention with the botanical definition which differentiates what between the seeds used in the case of municipal beans and grains in the case of barley, wheat, pearl millet and corn, as well as for the case of displaying the data and to prevent any error when talking about both of them.

Seed viability indices.

1 -Germination test.

The Petri dish method was used to perform the seed germination test suggested by the International Seed Test Organization (ISTA, 1966) as follows: The seeds used in the study (250 seeds from each crop year/crop) were chosen so that they were similar in size and free from any apparent damage that could be seen with the naked eye. The seeds were surface disinfected by soaking them for 30 seconds in Benlate fungicide {Methyl-(butyl carbamoyl) -2-benzimidazole carbamate} at a concentration of 0.3% (3 grams/liter distilled water). After treatment, the seeds are washed with distilled water several times in order to get rid of the remnants of the fungal disinfectant from the surface of the seeds. The seeds were distributed after treatment with disinfectant on five petri dishes (plastic and sterilized, and each dish has three pieces of filter paper, sterilized and impregnated with distilled water to plant the seeds on them). So that each dish contains fifty seeds that are distributed regularly inside the dish (to prevent crowding the seeds on one side of the dish, which affects the efficiency of the test), and consider each petri dish as one replicate. After planting the seeds in petri dishes and covering each dish with its own cover (to reduce the speed of water evaporation during germination), the dishes were placed with the seeds in the incubator with the appropriate temperature set for germination of each type of seed used in the study, namely: barley (20^{O}C) – pearl millet (27^{O}C) wheat (20^{O}C) - corn (27^{O}C) - broad bean (20^{O}C). The seeds were left at the appropriate temperatures for germination for a period of 120 hours, during which the percentage of germination was calculated during the time periods: 24, 48, 72, 96, 120, hours of sowing. Taking into account that the emergence of the root and its visibility with the naked eye was used as a criterion for seed germination.

2 -Seed quality index (QI).

This evidence is useful for knowing which of the tested seeds gave the highest germination rate in the first time periods of the germination test, and was calculated according to the following equation suggested by ISTA (1966):

$QI = Ni / \sum Ti$ Where:

N = number of germinated seeds during the time period (i). T = Number of days (in hours) of sowing

٣

- Seed vigour index (VI).

This evidence is useful for knowing which of the tested seeds give strong seedlings for growth and was calculated according to the following equation suggested by Abdul-Baki and Anderson (1973):

$VI = G\% \times L\,(E+R)$ Where:

G% = the percentage of germination at the end of the germination test period.

L (E+R) = length of both the epicotyl axis and the root (cm) at the end of germination test.

4- Seedling growth measurements.

Samples were taken to measure seedling growth parameters 48, 72, 96 and 120 hours after sowing seeds, and each time 10 seedlings were taken from each repeat for each crop year, and then they were separated into two parts:- the epicotyl axis and a root (in addition to the rest of the germinated seeds).

The following measurements were recorded on the previous parts:

1-Length of both epicotyl and root.

The length of the epicotyl was done by measuring 10 axes in each of the aforementioned time periods, then taking the average. As for the original root length, it was only measured after 120 hours from the seeds sowing and also according to the average length of ten roots.

2- Fresh and dry weights of epicotyl, root and germinated seeds.

Where the fresh and dry weight of ten epicotyl axes, roots and germinated seeds (germinating seed residues) were estimated from each replication for each crop year, after only 120 hours of sowing the seeds. The fresh weight was estimated immediately after sampling. The samples were then dried in a drying oven at a temperature of 70°C/48 hours to calculate their dry weight. As for the remnants of germinated seeds after 120 hours of sowing the seeds, the percentage of dry weight loss was calculated, expressed on the basis of the fresh weight (air-dried) of these seeds before sowing (0-time).

3- Seed imbibition: water uptake and solutes leakage measurements.

For this experiment, 150 seeds were selected from each crop year (with the exception of the pearl millet crop, where 600 seeds were taken from each crop year) so that the seeds were similar in size and free from any visible damage to the naked eye, and noting that this number of seeds was done. Repeat it with each time period during the duration of the experiment (which is one hour of duration is 5 hours). These seeds were distributed in three replicates for each crop year, then the weight of each duplicate (50 seeds for each crop or 200 in the case of pearl millet) and these weights were considered as representative of the weight of the seeds before they were placed in the water for imbibition (F_1). Each refined seed was placed in a 150 ml glass beaker containing 50 ml distilled water, and each beaker was covered with aluminum foil (to prevent water evaporation during the experiment).

After that, the beakers with the seeds were placed in an incubation at a constant temperature (the temperature of seed germination, which was previously mentioned in the germination test) for a period of 5 hours.

The following measurements were recorded every hour for 5 hours:

1- Water uptake% by imbibed seeds.

As this percentage was estimated by removing the seeds from the water soaked in it every hour during the duration of the experiment (5 hours). This is followed by drying the seeds directly on filter paper (to remove water attached to them overloaded while imbibing). The seeds were weighed immediately after drying and the weight was recorded (F_2). Then the percentage of water absorbed (WI) was calculated by the impregnated seeds as follows:

$WI= F_2-F_1/F_1\times100$

٢-Electerical conductivity (EC).

The EC was measured using an electro-conductometer model (D8120-Weilheim (WTW CO., Germany), where the electrode of the device was dipped directly into the water soaked in the seeds every hour during the imbibition period (5 hours), then the device reading was recorded in mhos.

Statistical analysis.

The complete randomized design in this study, analysis of variance, and calculation of the lowest significant difference (LSD) at the 5% significance level was performed according to what was reported by Snedecor and Cochran. (1967).

3. RESULTS AND DISCUSSION

I-Seed viability indices.

1- Germination%.

The results recorded in Table (3) show that the germination% increased gradually with the increase of the period of germination and that for all crop years for all crops to which the seeds used in the study (stored and not stored) belonged. It also appears that during the period of germination, the highest germination% was recorded by non-stored seeds, which is for the year 2019, compared to the other crop years (2018, 2017) to which all stored seeds belong. It is also noted from the results that there is an inverse relationship between the germination% of stored seeds and the period of storage, as this percentage decreases with the increase in seed storage time for all crops whose seeds were used in the study. This means that storing the seeds under non-controlled environmental conditions (open storage) for different years, it significantly affects the germination of the seeds, leading to a slow emergence of the root (germination evidence in this research) and thus the decrease of the germination capacity at a decreasing rate commensurate with the length of the storage period. It follows from this that the low germination percentage in stored (old) seeds indicates that the seeds lose their viability as they age. These results are in agreement with the findings of Teckrony et al. (1993),

Table 3. Germination% of different crops seeds during different crop years

Crop and crop year		Germination time (h from sowing)				
		٢٤	48	٧٢	٩٦	١٢٠
Barley	٢٠١٩	٠٠,٠	٥٢,٤	٧٨,٤	٨٢,٤	٨٤,٤
	٢٠١٨	٠٠,٠	٠٠,٠	١٢,٤	١٤,٨	١٩,٦
	٢٠١٧	٠٠,٠	٠٠,٠	٠٠,٤	٠٣,٢	٠٦,٤
	LSD(0.05)	-	-	٨,١٣	٩,١٠	١١,٣
Pearl millet	٢٠١٩	٦٥,٢	٩١,٨	٩٦,٤	٩٨,٠	٩٨,٠
	٢٠١٨	٥٢,٨	٩٠,٤	٩٤,٨	٩٤,٨	٩٥,٦
	٢٠١٧	٠٠,٠	٤٤,٨	٩٠,٦	٩١,٦	٩١,٦
	LSD(0.05)	١,٢٠	٢,٥٠	١,٩٠	١,٤٩	١,٨٠
Wheat	٢٠١٩	٠٠,٠	٧٦,٨	٩٢,٠	٩٤,٠	٩٥,٦
	٢٠١٨	٠٠,٠	٧٠,٨	٨٩,٢	٩١,٦	٩٢,٢
	٢٠١٧	٠٠,٠	٦٠,٨	٨٤,٠	٨٨,٤	٩٠,٤
	LSD(0.05)	-	٣,٨٣	١,٦٧	١,٨٤	٢,٠١
Maize (corn)	٢٠١٩	٠٠,٠	١٨,٤	٦٧,٦	٨٧,٢	٩١,٦
	٢٠١٨	٠٠,٠	١٠,٨	٣١,٢	٥١,٦	٦٠,٨
	٢٠١٧	٠٠,٠	٠١,٦	٢٣,٢	٤٦,٨	٥١,٨
	LSD(0.05)	-	٣,٣٦	٧,٠٨	٧,٠٥	٧,٠٦
Broad bean (Horse bean)	٢٠١٩	٠٠,٠	٠٤,٤	٢١,٦	٧٠,٨	٩٢,٤
	٢٠١٨	٠٠,٠	٠٢,٢	١٧,٦	٦٧,٦	٨٨,٤
	٢٠١٧	٠٠,٠	٠١,٢	١٢,٤	٥٠,٤	٧٨,٨
	LSD(0.05)	-	١,٩٠	٤,٠٠	٨,٠٣	٦,٧٠

Tenne et al. (1980), and EL-Bagoury et al. (1980) and Bharat et al. (1993) on soybean seeds.

٢-Seed vigour and quality indies.

The results shown in Table (4) show that the quality of seeds (QI) decreased by increasing the period of storage in all the different crop years used in the study. The 2019 harvest for all crops (which represents non-stored seeds) gave the highest value in terms of seed quality compared to the remaining crop years shown in the previous table. This indicates that the seeds not stored

Table 4. Seed quality and seed vigour indices (120 h of seed sowing) for seeds of different crops during different crop years.

Crop and crop year		Seed quality index (QI)	Seed vigour index (VI)
Barley	٢٠١٩	٨٩,٨٨	٦٣٤,٦٩
	٢٠١٨	١١,٧٥	١٣٢,٨٩
	٢٠١٧	٠٢,٢١	١٧,١٥
	LSD(0.05)	٨,٠٨	١١٣,٧٠
Pearl millet	٢٠١٩	١٨٧,٣٣	٨٦٤,٣٦
	٢٠١٨	١٧٦,٦٢	٤٥١,٠٩
	٢٠١٧	٩٣,٨٥	٣٨٢,٨٩
	LSD(0.05)	٦,٩٨	١١٧,١٣
Wheat	٢٠١٩	١١١,٧٢	٦٨٤,٤٩
	٢٠١٨	١٠٦,٤٧	٥٠٧,١٠
	٢٠١٧	٩٨,٥٢	٤٤٨,٣٨
	LSD(0.05)	٢,٨٠	٤٧,٠٣
Maize (corn)	٢٠١٩	٧١,٨٥	٥٦٩,٧٥
	٢٠١٨	٤٠,٨٦	٢٦٠,٢٢
	٢٠١٧	٣٣,٠٩	٢١١,٣٤
	LSD(0.05)	٢,٤٢	٣٧,٠٧
Broad bean (Horse bean)	٢٠١٩	٤٥,٦٦	٥٠٢,٦٦
	٢٠١٨	٤١,٦٥	٤٠١,٣٤
	٢٠١٧	٣٣,٠٩	٣٣٢,٥٤
	LSD(0.05)	٢,١٥	٢٢,٠٢

(harvest season 2019) are considered the best seeds in their quality, while the seeds of the 2017 crop year in barley, pearl millet, wheat, corn and broad bean are among the worst seeds used in terms of their quality. The previous table also shows that the seeds not stored for the 2019 harvest season for all crop years recorded a significant increase in seed vigour (VI) compared to the other crop years and that this increase increased with the length of the seed storage period for all crops. As the 2017 seeds were also recorded in barley and pearl millet, wheat, corn and broad bean are of less value in terms of seed vigour. It follows from this that the low quality and vigour of stored seeds compared to non-stored seeds indicates the inability of stored seeds to germinate and give strong seedlings when they age (increase the storage period). These results are consistent with the findings of Abdul-Baki and Anderson (1973), who considered that the embryonic axes (the epicotyl and the root) are the places of seed vigour in which some metabolic changes occur and are associated with the occurrence of a loss in seed vigour and they suggested that the decrease in seed vigour is primarily due to a decrease in the respiratory rate and a deficiency in the representation of carbohydrates and proteins, as well as an increase in the rate of permeability of cellular membranes for those substances needed by the embryo during its development.

II -Seedling growth parameters.

1- Length of epicotyl and root.

The changes in the length of both the epicotyl during the periods of germination (48, 72, 96, and 120 hours) and the root (120 hours of germination) and the incident induce the effect of loose storage of the seeds used in the research, shown in Table (5). The results show that storing seeds for different periods of time has led to a significant decrease in the length of the epicotyl by increasing the storage period, as 2019 seeds of all crops whose seeds were used in the study recorded the largest value in the length of the epicotyl during the aforementioned germination periods compared to the other crop years used, whose periods range between 1, 2 years for different crops. As for the length of the root after 120 hours of sowing the seeds, which is also shown in the previous table, it was also recorded a significant decrease by increasing the length of storage time for all the seeds under investigation. And taking into account that the length of the rootstock after this period of seeding (120 hours) was affected to a greater extent by the increase in the storage period compared to the length of the embryonic axis in the same period of germination. Hence, it can be said that the length of both the epicotyl axis and the root decreases with increasing storage period. Such results are consistent with the findings of Gill (1977), who found that the length of both the epicotyl and the root produced from the seeds of the broad bean decreases with the increase in the period of storage of the seeds and that this decrease in the length of both is due to the occurrence of decreased seedling growth potential as reported by Alizaga et al. (1987) on soybeans.

Table 5. Length of epicotyl and root of geminated seeds for different crops during different crop years

Crop and crop year		Length of epicotyl (cm)				Root length (cm)
		Germination time (h from sowing)				
		٤٨	٧٢	٩٦	١٢٠	١٢٠
Barley	٢٠١٩	١,٦٤	٢,٠٤	٢,٣٦	٤,٣٤	٣,١٨
	٢٠١٨	(-)	١,٢٤	١,٦٦	١,٦٩	١,٨٢
	٢٠١٧	(-)	١,١٠	١,١٨	١,٤٠	١,٢٨
	LSD(0.05)	-	٠,٩٠	٠,٥٦	٠,٨٣	٠,٤٥
Pearl millet	٢٠١٩	١,٥٨	١,٦٤	٢,٩٤	٥,٠٢	٣,٨٠
	٢٠١٨	١,١٢	١,٥٠	٢,٤٦	٣,٠٢	٢,٦٤
	٢٠١٧	٠,٦٠	٠,٨٤	١,٥٢	٢,٣٤	١,٨٤
	LSD(0.05)	٠,٣١	٠,٤٦	٠,٨٢	١,٠٣	٠,٩٥
Wheat	٢٠١٩	١,٧٠	٢,٠٦	٢,٥٤	٤,٠٠	٣,١٦
	٢٠١٨	١,٠٦	١,٤٨	١,٩٢	٣,٠٠	٢,٥٠
	٢٠١٧	١,٠٢	١,٤٠	١,٩٠	٢,٧٦	٢,٢٠
	LSD(0.05)	٠,٩٧	٠,٨٠	٠,٨١	٠,٤٥	٠,٣٣
Maize (corn)	٢٠١٩	١,٥٠	٢,١٨	٢,٨٦	٣,٦٤	٢,٥٨
	٢٠١٨	٠,٨٤	١,١٤	١,٧٠	٢,٣٦	١,٩٢
	٢٠١٧	٠,٧٤	١,٠٦	١,٦٠	٢,٢٠	١,٨٨
	LSD(0.05)	٠,٥٠	٠,٦٣	٠,٧١	٠,٨٤	٠,٥٣
Broad bean (Horse bean)	٢٠١٩	(-)	٢,٠٢	٢,٤٤	٢,٩٨	٢,٤٦
	٢٠١٨	(-)	١,٦٣	٢,٠٠	٢,٣٨	٢,١٦
	٢٠١٧	(-)	١,٤٨	١,٨٦	٢,٢٤	١,٩٨
LSD(0.05)		-	٠,٣٢	٠,٤١	٠,٢٣	٠,٢٦

2- Fresh and dry weights of epicotyl and root

The changes in the fresh and dry weight of the epicotyl and the root after 120 hours of sowing the seeds, which are shown in Table (6) show that the fresh weight of both the epicotyl and the resulting root of the non-stored seeds (2019), its value was higher than that of the seeds stored for different crop years and tested in the research, and with a clear decrease in the fresh weight, directly proportional to the length of the storage period of seeds belonging to different crops. The same table also shows that the dry weight of the epicotyl axis and root exhibits the same pattern that occurred in the case of fresh weight in terms of increasing its value in unstored seeds compared to non-stored and with increasing this difference by increasing the length of storage time of seeds used in the study. It seems that the decrease in both the fresh and dry weight, which is shown in the previous table, is due to the loss of the seeds' vitality during storage and the inability of the embryonic axes (the epicotyl and the root) to represent the necessary metabolic compounds, which in turn contribute to the increase in the fresh and dry weight of the embryonic axes due to the effect of the process of representing these compounds by losing their viability during storage (Abdul-Baki and Anderson (1973) and similar results were also presented by EL-Bagoury et al. (1980) on soybean seeds

٣– Loss% of dry weight in germinated seeds.

Table (7) show dry weight loss% for germinated seeds after 120 hours of sowing. It is evident from the data recorded in this table that all the tested seeds recorded a clear decrease in their dry weight at the end of the germination period (120 hours) for all different crop years, noting that the loss% in the case of non-stored seeds (2019) recorded its lowest value compared to the other crop years of the different crops to which the tested seeds belong, and that this percentage differs from one crop to another. It follows from this that the percentage of dry weight loss of stored seeds at the end of the germination period increases with increasing seed storage time, and this may be due to the increased permeability of stored seeds for many materials that contribute to the calculation of dry weight (Carbohydrates-proteins-salts ... etc.). In addition to what is consumed from the seed stock in building the new cells that make up the embryonic axes (the epicotyl and the root), in comparison with the non-stored seeds in which the dry weight loss depends primarily on what is consumed of the material from the dry seeds stored in the building of new cells and tissues of the embryonic axes, and this is clearly shown in Table (7) which shows the apparent increase in the dry weight of the embryonic axes resulting from the non-stored seeds compared to their stored ones. The data recorded in Table (9) regarding the degree of electrical conductivity (EC) of the leaked solutes from the seeds to the external medium, from which an increase in the EC value is observed in the case of stored seeds compared to that recorded by non-stored seeds.

Table 6. Fresh and dry weight of roots and epicotyls (g/10 roots or epicotyls/120 hours after sowing) of different crop seedlings during different crop years

Crop and crop year		Roots weight (g)		Epicotyl weight (g)	
		Fresh	Dry	Fresh	Dry
Barley	٢٠١٩	١,٤٦٤	٠,٣٧٦	١,٦٧٢	٠,٤١٩
	٢٠١٨	١,٤١٤	٠,٣٥١	١,٥٧٦	٠,٣٩١
	٢٠١٧	١,٣٥٦	٠,٣٢١	١,٥٣٠	٠,٣٧٤
	LSD(0.05)	٠,٠٥٧	٠,٠١٧	٠,٠٣٧	٠,٠٣٨
Pearl millet	٢٠١٩	٠,٩٠٣	٠,٢٢٤	١,٠٨٠	٠,٢٧٠
	٢٠١٨	٠,٨١٧	٠,٢٠٥	١,٠٣٤	٠,٢٥٦
	٢٠١٧	٠,٧٩٥	٠,١٩٤	١,٠١٢	٠,٢٤٧
	LSD(0.05)	٠,٠٢٠	٠,٠١٠	٠,٠١٩	٠,٠٠٩
Wheat	٢٠١٩	١,٤٦٠	٠,٣٧١	١,٦٤٠	٠,٤١١
	٢٠١٨	١,٤١٤	٠,٣٥٩	٠,٦٠٠	٠,٣٩٨
	٢٠١٧	١,٤٠٨	٠,٣٥٣	١,٥٥٠	٠,٣٨١
	LSD(0.05)	٠,٠١٣	٠,٠٠٨	٠,٠٨١	٠,٠١٦
Maize (corn)	٢٠١٩	٠,٨٥٨	٠,٢١٥	١,٨٢٨	٠,٤٥٨
	٢٠١٨	٠,٥٥٧	٠,١٣٨	١,٥٨٤	٠,٣٩٤
	٢٠١٧	٠,٤٥٤	٠,١١١	١,٤٥٤	٠,٣٥٥
	LSD(0.05)	٠,٠٩٩	٠,٠١٨	٠,١٢٠	٠,٠٧٠
Broad bean (Horse bean)	٢٠١٩	٢,٥٧٨	٠,٦٤٧	١,٨٩٤	٠,٤٧٤
	٢٠١٨	٢,٣٣٦	٠,٥٧٨	١,٦٦٠	٠,٤١٢
	٢٠١٧	١,٨٨٢	٠,٤٦٠	١,٥٣٨	٠,٣٧٢
	LSD(0.05)	٠,١٩١	٠,٠١٣	٠,١١٦	٠,٠٣١

Table 7. Dry weight loss% (g/120 hours of sowing) seeds for different crops during different crop years

Crop and crop years		Dry weight loss%
Barley	٢٠١٩	٤٠,٥٨
	٢٠١٨	٤٨,٨٧
	٢٠١٧	٥٦,٣٢
	LSD(0.05)	**٣,٩٤**
Pearl millet	٢٠١٩	٢٢,٢٢
	٢٠١٨	٣٤,١٣
	٢٠١٧	٣٨,٥٦
	LSD(0.05)	**٢,٣٥**
Wheat	٢٠١٩	٢١,٩٠
	٢٠١٨	٢٥,١٢
	٢٠١٧	٣٥,١٥
	LSD(0.05)	**٢,٥٩**
Maize (corn)	٢٠١٩	٢١,٦٥
	٢٠١٨	٢٥,٤٤
	٢٠١٧	٧٩,٣٠
	LSD(0.05)	**٢,٣٩**
Broad bean (Horse bean)	٢٠١٩	٣١,٢٣
	٢٠١٨	٦٥,٨٢
	٢٠١٧	٣٧,٤٥
	LSD(0.05)	**3.11**

These results are in agreement with the findings of Parrish and Leopold (1978) who found that stored soybean seeds lost more than 10% of their dry weight when soaked in water and that this loss was mainly due to changes in the cellular membranes of the stored seeds, thus losing them its control on the penetration of solutes to the outer environment.

III -Water uptake and Solutes leakage during seed imbibition:

1- Water uptake

The results recorded in Table (٨) show that there is a clear increase in the rate of absorption or imbibition of water during the period of soaking the tested seeds (5 hours), whether stored or not (average of 200 seeds). This is for the different crop years, although there are relative differences between the rates of water absorption by seeds from one crop year to another and from one crop to another. Where we find that storing seeds for all crops has led to a significant decrease in seed absorption of water, this deficiency increases significantly with the increase in seed storage time, as it was more valuable in the case of 2017 seeds in the case of barley, pearl millet, wheat, corn and broad bean seeds compared to the other crop years. Such results may be due to a change in the nature of the structure of the membrane system of seeds during storage, in agreement with Parrish and Leopold (1978), which they reached through their studies on the mechanism of the loss of seed viability during storage, as they showed that stored seeds lose the ability to generate pressure. Internal osmotic pressure, which in turn is due to the destructive changes that occur in the composition of the cellular membranes of stored seeds, which accompanies it loss of its ability to maintain a high level of osmotic pressure that helps it to absorb water and thus its ability to absorb with water when stored.

Table 8. Water uptake* (%) by the seeds soaked in the distilled water of different crops during the crop years

Crop and Crop years		Imbibition time (h)				
		١	٢	٣	٤	٥
Barley	٢٠١٩	٢١,٤٣	٢٩,١٢	٣٣,٠٧	٣٤,٠٧	٣٨,٣٢
	٢٠١٨	١٩,٧٣	٢٦,٤٦	٣٠,٦٦	٣٢,٤٣	٣٤,٣٨
	٢٠١٧	١٨,٥٠	٢٥,٤٤	٢٦,٧٩	٣٢,٠٠	٣٣,٨٠
	LSD(0.05)	٠,٨١	٠,٩٣	٢,٨٣	١,٠٣	١,٦١
Pearl millet	٢٠١٩	١٧,٧٤	٢٨,٥٧	٣٣,٩١	٣٧,٥٢	٥٠,٦٦
	٢٠١٨	١٥,١٣	٢٣,٠٤	٣٠,٧٣	٣٤,٩٥	٣٧,٣٦
	٢٠١٧	٠٩,٧٨	١٧,٥٩	٢٤,٨٠	٢٥,٨١	٢٩,٢٨
	LSD(0.05)	٤,٤١	٥,١١	١١,٠٣	٨,٦٧	٧,٦٧
Wheat	٢٠١٩	٠٩,٧٨	١٧,٥٩	٢٤,٨٠	٢٥,٨١	٥٢,٢٨
	٢٠١٨	١٣,٨٩	٢٠,٣٧	٢٧,٠٤	٣٣,٤٩	٣٤,٩٦
	٢٠١٧	١١,٢٢	١٩,١٨	٢٦,٥٧	٣٠,٩٤	٢٣,٧٠
	LSD(0.05)	١,٨١	١,٠١	٠,٣٩	٢,١١	٠,٩٧
Maize (corn)	٢٠١٩	١٥,١٣	٢٠,٥٠	٢٤,١٦	٣١,١٥	٣٩,١٣
	٢٠١٨	٠٨,٤٩	١٢,٠٩	٢٣,١١	٣٠,٥٥	٣١,٢٠
	٢٠١٧	٠٧,٥١	١١,٥٧	١٧,٤١	٢٧,٥٧	٢٩,٩٠
	LSD(0.05)	١,٨١	١,٠١	٠,٣٩	٢,١١	٠,٩٧
Broad bean (Horse bean)	٢٠١٩	٠٩,٧٢	٢٢,١٤	٤٦,١٠	٦٦,٨١	٧٤,١٤
	٢٠١٨	٠٦,٠٨	١٩,٨٨	٢٢,٥٧	٤٦,١٠	٦٦,٨١
	٢٠١٧	٠٤,٦٠	١٨,٣٧	٢٢,١٤	٣٥,٦٥	٦٠,٨١
	LSD(0.05)	٠,٩٢	١,١٣	٠,٣٧	٧,٨١	٣,٣٧

* Expressed as a percentage of the seeds' fresh weight before imbibition.

2- Solutes leakage.

1- Electrical conductivity of solutes leakage.

The data recorded in Table (9) show that the loss of solutes (electrolytes) from stored and non-stored seeds and their leakage to the external medium (steeped water) increases with the progression of a period of the seeds imbibition. Noting that there is a clear difference between the different crop years in the rate of soluble leakage from their seeds. These differences are inversely related between the degree of electrical conductivity (EC) and the duration of storage, as the rate of leakage of solutes increases with the increase in seed storage time. In addition, this inverse relationship is also clear between the rate of solvent leakage and the viability of the seeds, as we find that the seeds with a high electrical conductivity have a low degree of vitality and vice versa. The leakage of solutes at a high rate in the case of stored seeds compared to non-stored ones may be due to a change in the composition of the cellular membranes of the seed, which is followed by a loss of its control over the penetration of these solvents and thus their leakage into the impregnation medium. These results are similar to what Oliveira et al. (1984) obtained for soybean seeds, in which they showed that the seeds with the highest solute leakage rate (the highest EC value) had the lowest biocompatibility and attributed this to catabolic changes in the composition of the cellular membranes of the stored seeds.

Table 9. Electrical conductivity* (EC) of the leaked solutes (umhos/50 seeds/50 ml distilled water) for the seeds of different crops during the different crop years.

Crop and Crop years		Imbibition time (h)**				
		١	٢	٣	٤	٥
Barley	٢٠١٩	٢٠	٢٥	٤٥	٤٠	٦٠
	٢٠١٨	٢٥	٣٨	٢٤	٦٠	٨٦
	٢٠١٧	٤٠	٥٥	٧٠	٨٨	٩٢
	LSD(0.05)	٤,١	٩,٢	٨,٠	١٣,٧	١٧,١
Pearl millet	٢٠١٩	١٧,٧٤	٢٨,٥٧	٣٣,٩١	٣٧,٥٢	٥٠,٦٦
	٢٠١٨	١٥,١٣	٢٣,٠٤	٣٠,٧٣	٣٤,٩٥	٣٧,٣٦
	٢٠١٧	٠٩,٧٨	١٧,٥٩	٢٤,٨٠	٢٥,٨١	٣٩,٢٨
	LSD(0.05)	٤,٤١	٥,١١	١١,٠٣	٨,٦٧	٧,٦٧
Wheat	٢٠١٩	٠٩,٧٨	١٧,٥٩	٢٤,٨٠	٢٥,٨١	٥٢,٢٨
	٢٠١٨	١٣,٨٩	٢٠,٣٧	٢٧,٠٤	٣٣,٤٩	٣٧,٩٦
	٢٠١٧	١١,٢٢	١٩,١٨	٢٦,٥٧	٣٠,٩٤	٣٢,٧٠
	LSD(0.05)	١,٨١	١,٠١	٠,٣٩	٢,١١	٠,٩٧
Maize (corn)	٢٠١٩	١٥,١٣	٢٠,٥٠	٢٤,١٦	٣١,١٥	٣٩,١٣
	٢٠١٨	٠٨,٤٩	١٢,٠٩	٢٣,١١	٣٠,٥٥	٣١,٢٠
	٢٠١٧	٠٧,٥١	١١,٥٧	١٧,٤١	٢٧,٥٧	٢٩,٩٠
	LSD(0.05)	٠,٨٧	٠,٤٧	٣,٨٩	١,٩٧	٠,٩٣
Broad bean (Horse bean)	٢٠١٩	٠٩,٧٢	٢٢,١٤	٤٦,١٠	٦٦,٨١	٧٤,١٤
	٢٠١٨	٠٦,٠٨	١٩,٨٨	٢٢,٥٧	٦٤,١٠	٦٦,٨١
	٢٠١٧	٠٤,٦٠	١٨,٣٧	٢٢,١٤	٣٥,٦٥	٦٠,٨١
	LSD(0.05)	٠,٩٢	١,١٣	٠,٣٧	٧,٨١	٣,٣٧

* Expressed as a percentage of the seeds' fresh weight before imbibition.
** Mean of 200 seeds

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الملخص العربى

دراسات فسيولوجية على البذور المخزنة لبعض المحاصيل

زينب ضو المريض
قسم البيولوجي - كلية التربية-زوارة-جامعة الزاوية-ليبيا

مما لاشك فيه أن حيوية البذور (قوة وقدرة البذور علي الإنبات) تعد من العوامل الضرورية اللازمة للحصول على كثافة نباتية عالية الإنتاج المحاصيل، وقد تتأثر حيوية البذور عكسيا أثناء التخزين بواسطة العوامل البيئية مسببة فقد حيوية هذه البذور. لذا فإن فقد حيوية البذور تعد إحدى المشاكل التي تواجه الإنتاج الزراعي والتي لاقت إهتماما بحثياً متزايداً نظراً لأن المعلومات المتعلقة بالأسباب المؤدية لفقد حيوية البذور لم تكتمل تفاصيلها بعد.

لهذا، فإن هذا البحث إستهدف دراسة التغيرات الفسيولوجية أثناء مرحلة الإنبات المبكرة في البذور المخزنة لبعض المحاصيل تحت الظروف البيئية (حرارة ورطوبة) غير المحكمة (تخزين مفتوح)، في محاولة للتعرف على التغيرات الفسيولوجية المرتبطة بفقد حيوية البذور أثناء التخزين. ولتحقيق ذلك، فقد أستخدمت بذور محاصيل القمح - الشعير - القصب - الذرة - الفول البلدي والتي تم حصادها في مواسم مختلفة (٢٠١٧، ٢٠١٨، ٢٠١٩) حيث تمثل مواسم ٢٠١٧، ٢٠١٨ البذور المخزنة لمدة عامين، عام على التوالي تحت ظروف التخزين غير المحكم، أما بذور موسم ٢٠١٩، فقد أستخدمت كبذور غير مخزنة للمقارنة (كنترول).

ويمكن تلخيص النتائج المتحصل عليها فيما يلي:

(أ)- دلائل حيوية البذور: لوحظ أن تخزين بذور المحاصيل المستخدمة في الدراسة لعدة سنوات مختلفة أثر معنوياً في إنبات البذور ونتج عنه تأخر في إنبثاق الجذير (دليل الإنبات) ونقص القدرة الإنباتية بمعدل متناقص مع زيادة طول فترة التخزين لجميع البذور المستخدمة في الدراسة. وجد أن دلائل جودة وقوة البذور قد إنخفضت بزيادة مدة التخزين لجميع البذور المستخدمة في البحث. **(ب) معايير نمو البادرات:** أظهرت نتائج الوزن الرطب والجاف لكل من السويقة الجنينية العليا والجذر (في نهاية فترة الإنبات/١٢٠ ساعة) تناسب عكسيا مع طول مدة التخزين لكافة البذور المستعملة في البحث. أدى تخزين البذور إلى نقص معنوي في النسبة المئوية لفقد الوزن الجاف للبذور المستنبتة (بقايا البذور النابتة في نهاية فترة الإنبات) بمعدل متناقص مع زيادة فترة التخزين. أدى تخزين البذور لعدة سنوات مختلفة إلى نقص معنوي في طول كل من السويقة الجنينية العليا والجذر (خلال وفي نهاية فترة الإنبات على التوالي) بمعدل متناقص مع زيادة فترة التخزين، كما لوحظ أن طول الجذر قد تأثر بدرجة أكبر نسبية بالمقارنة بطول السويقة الجنينية العليا. **(ج) إمتصاص الماء وتسرب الذائبات:** أظهرت البذور المخزنة نقصاً معنوياً في إمتصاص الماء، حيث إزداد هذا التأثير المتناقص وضوحا بزيادة مدة التخزين. وجد أن درجة التوصيل الكهربائي (EC) للذائبات المتسربة من البذور تتناسب عكسيا مع حيوية البذور، حيث أعطت البذور منخفضة الحيوية درجة توصيل كهربائي عالية والعكس صحيح ولوحظ ذلك في كافة البذور المستخدمة في الدراسة.

وتشير الكميات المتسربة و المتزايدة مع زيادة عمر البذور إلى حدوث تلف في الغشاء الذي يحد من تسرب هذه الذائبات من الأنسجة وبالتالي يؤدي هذا التسرب إلى ضعف نمو البادرات لإستنفاذ مركبات الأيض اللازمة للنمو وتسربها خارج البذور. **وأخيرا**، يوصي بمواصلة البحث فيما يتعلق بالتغيرات الكيميائية المرتبطة بفقد حيوية البذور أثناء التخزين (المفتوح) والتي لم نتمكن من خلال هذا البحث من دراستها عن قرب، وذلك نظراً للدور الذي قد تلعبه هذه التغيرات في إحداث تدهور للبذور أثناء تخزينها وبمعرفة مثل هذه التغيرات ومع ماسبق الوصول إليه من تغيرات فسيولوجية يمكن بالتالي الوصول الى أمثل الطرق للحفاظ على حيوية البذور أطول فترة ممكنة.

الكلمات الدالة: البذرة- الحيوية- الإنبات- التخزين- التغيرات الفسيولوجية.