Journal of Global Biosciences
ISSN 2320-1355
Volume 4, Number 5, 2015, pp. 2199-2211
Website: www.mutagens.co.in
E-mail: submit@mutagens.co.in
researchsubmission@hotmail.com

Research Paper

SEED ECOLOGY OF *Plantago* SPP. GROWING IN SOUTH SINAI, EGYPT

Abd El-Raouf A. Moustafa, Mohamed S. Zaghloul, and Dina H. Alsharkawy

Botany Department,
Faculty of Science,
Suez Canal University, 41522 Ismailia,
Egypt.

Abstract

The vegetation and wild life in Saint Catherine area is subjected to great disturbance through the unmanaged human activities. In the present study we had used seed ecology in order to contribute in designing a sound long term conservation plan for the two threatened endemic studied medicinal species; *Plantagosinaica*, and two other *Plantago* species; *P. ovata*and *P. lagopus* at three levels; (a) studying the germination response at different conditions and pretreatments on wetted substrate (b) the effect of moisture content percentage on the germination during different storage periods and (C) the effect of burying on seed longevity and viability. For the three*Plantago* species there was a great variation in the behavior of seed germination among them, we observed that sulphoric acid (H_2SO_4) was the only treatment that enhanced germination in the three species at least at one of the temperature treatments. The moisture isotherm of *P. ovata*and *P. sinaica*revealed a positive correlation with germination and negative one with storage period, one can say that *Plantagosinaica* and *Plantagoovata* seeds are orthodox as it prefers low moisture and there was a negative correlation between germination and moisture content with a significant correlation coefficient (r = 0.622 and P= 0.006).The depth of buried seeds seem to be protective to an extent as the highest germination percentages after one year (80 and 91%) were that at 2 cm depth in the loamy and clay soil respectively.As a general conclusion, the present study clarified that the behavior of the three species along environmental gradients is similar to a great extent in storage behavior, but it differs in the germination behavior, as well as in the strategies in struggling for existence.

INTRODUCTION

The genus *Plantago*comprises 265 species and has a cosmopolitan distribution [1]. *Plantago* species have been found in temperate regions and in tropical zones [2] including the varied ecological systems required by the plant to adapt both phenotypically and physiologically[3], [4]..Species of the genus *Plantago* grows in almost every type of habitat including deserts, sea cliffs, woodlands; disturbed areas and tropical mountains [5].The genus *Plantago*comprises 21 species growing in Egypt, some of them are very rare; others are common either in the desert or the cultivated land [6].

Maintenance of seed viability over time is affected by many factors, including species, soil type, depth of burial, and tillage frequency. For example, as seed burial depth increased, seed

longevities usually increased [7], [8]; this response is primarily due to lack of germination from lower depths caused by lack of light, stable temperature and water levels, and low oxygen levels [9].Investigation reported a large heterogeneity and inequality for longevity between seeds originating from different plant species [10]. When seeds deteriorate during storage, they lose vigor, become more sensitive to stresses during germination and ultimately become unable to germinate. The rate of aging is strongly influenced by environmental and genetic factors such as storage temperature, seed moisture content, and seed quality[11].

In the context of climate change, plant genetic composition may change in response to the selection pressure and some plant communities or species associations may be lost as species move and adapt at different rates [12]. Seed conservation (in situ or ex situ) is one of the best strategies for the conservation of plant diversity.

The purpose of this research was to study the effects of some chemical presoaking treatments (calcium carbonate, gibberellic acid, sulphoric acid, citric acid and hot water), temperature, and burial time on three *Plantago* species; *P.ovata, P.sinaica*and *P.lagopus* seed germination and seedling emergence, and to design a moisture isotherm curve for *Plantago* species.

MATERIALS AND METHODS

Germination behavior

Seed collection of study species was carried out in the period from February to April 2013; *P. sinaica* seeds were collected from the Saint Catherine area, *P. lagopus* from the Suez Canal campus gardens and *P. ovata* from the market. Seeds were stored in the laboratory conditions till germination tests. In the period from May to October 2013 preliminary germination experiments were carried out in laboratory conditions to determine the germination behavior and dormancy (if present) for each species.

For the three *Plantago* species, the seeds were pre-treated by soaking in different concentrations of gibberellic acid (GA), sulphoric acid (H_2SO_4), calcium carbonate ($CaCO_{3)}$, citric acid (CA), and hot water. Then seeds were sown on moistened cotton layer in Petri dishes. The used concentrations were as follows: 50, 100 and 200 mg/L GA; 0.5, 1 and 1.5% H_2 SO_4; 1, 2 and 3 % $CaCO_3$; and 0.1 and 1 % citric acid solutions, hot water pretreatment (80°C) for 5 and 10 minutes according to [13]. Germination treatments were carried out in Petri dishes, each containing 25 or 50 seeds, and were made in triplicates. Each treatment had been tested for germination under three different conditions; first at the laboratory conditions, second at 24°C ±2 in dark incubator and the third at 25/15°C and 16/8 light/dark incubator.

Longevity

Longevity test (burial experiment)

Seeds were placed in mesh envelopes prepared from tulle fabric, each envelope contained 50 seeds. The mesh of tulle fabric is small enough to retain the seeds but still allows for passage of water, gases and microorganisms through it. The envelope dimension was approximately 2.5 x 2.5 cm, the envelope size and number of seeds was selected according to the seed size modified from [14]. One-hundred and eight plastic pots were used and filled with different soil types, clayey, loamy and sandy soil. The basic soil amount was fixed in all pots, then a calculated volume of soil was put in each in order to get the desired depth one, one and half and two cm. After pots were filled with the basic fixed volume of soil, the seed envelopes were laid on the soil surface and then covered with the known volume of soil to get the desired depth. Pots were irrigated with a specific regime as they were divided into three groups, first group were irrigated three times per week, the second were irrigated two times per week, and the third were irrigated one time per week. After every three months during a year from the date of the experiment setup, the seed envelope of one of each depth from each group was picked up and was tested for viability by direct germination test.

Moisture content and moisture isotherm

Seed moisture content

Moisture content was determined by weighing empty crucibles with lids and clearly labels them with sample numbers - each sample was done in three replicates - then adding the seeds to the

crucibles with lids and re-weighed to record the fresh weight of the seeds, using approximately one gram of seeds in each crucible. Then the crucibles were placed in the oven for 1-4 hours at 130 °C, and then the samples were let to cool in desiccator for one hour, then crucibles are reweighed again as to record the dry weight, and then the moisture loss was expressed as percentage [15].

Preparing moisture isotherms

Moisture isotherms could be constructed by allowing seeds to reach equilibrium in environments with known relative humidity maintained by saturated salt solutions at a given temperature. Saturated salt solutions were prepared by adding the indicated salt to warm (about 40°C) distilled water with stirring until no more salt was dissolved. Additional salt was added to ensure an excess of the saturating salt.

Table (1) provides approximate compositions for saturated solutions [16]. After that, the prepared saturated salt solutions were placed in labeled glass jars at least 20% of the total volume. Seeds were weighed (approximately one gram) and packed in tulle fabric and then placed in the jars above the solutions. The jars then were sealed and allow enough time for seed moisture to equalize with the surrounding air. Seeds should either absorb or lose moisture depending on the gradient in water pressure between the seeds and surrounding air. When the weight of seeds remained unchanged, equilibrium moisture content was attained. Determining the equilibrium seed moisture content at each relative humiditywas carried out by oven-drying[17].

RESULTS

Germination behavior

Plantagosinaica

Hot water treatment (10mins), citric acid (0.1%) and H_2SO_4 (1.5%) showed high germination percentages comparing to control: it was 64% for H_2SO_4 (1.5%), which showed high significant $P \leq 0.003$, for hot water (10 mins) germination percentage was 69.33% andfor citric acid (0.1%) it was 81.33%, which was high significant $P \leq 0.003$.While gibberellic acid and calcium carbonate were suppressive to germination in different concentrations and at all germination temperature (Table 2). Temperature seemed to have a significant effect on germination of*P.sianica*, results showed great variation under temperature treatments it was highly significant at 0.5% as $P \leq 0.002$, at 1.5% $P \leq 0.004$ and at 1% $P \leq 0.009$.

Plantagoovata

Sulphoric acid (1.5%) treatments showed the highest germination percentages (96%) at both 25°C and 15/20°C, the other two concentrations (0.5% and 1%) resulted in 92% and 80% at 15/20°C,respectively, showing the highest percentages of seed germination when compared against untreated controls among all other treatments. But it was observed that other treatments didn't show any enhancement at room temperature as all the resulted percentages came less than the control.

Citric acid (0.1% and 1%) treatments resulted in its highest significant enhancement of germination; 70.66% and 73.33%, respectively, at 15/20°C , at the same temperature treatment, calcium carbonate of (1%, 2% and 3%) concentrations treatment showed its highest germination percentages; 80%, 70.66% and 72% respectively, and gibberellicacid (50 mg, 100 mg and 200 mg) concentrations treatment showed its maximum germination enhancement 70.66%, 73.33% and 67.05% respectively. Hot water treatment did not enhance germination; on contrarily it suppressed the germination at all temperature treatments comparing with the control, although it was highly significant in its relation with temperature treatments (Table 3).

Plantagolagopus

Sulphoric acid(1.5%) concentration treatment at room temperature showed highly significant germination percentages among all treatmentscomparing to control, as the P value was ≤ 0.000 according to the analysis of variances; 66.06%, 64% and 84% respectively at 25°C, 32%, 34.66% and 44%, respectively, at 15/20°C and 26.66%, 29.33% and 44%, respectively, at room temperature.

Citric acid showed fluctuation in germination percentage, as it showed high result (48%) with 0.1%, which was highly significant $P \leq 0.000$, and zero (0) with 1% at 25°C resulting in the lowest germination percent. Hot water, calcium carbonate and gibberellicacid reduced germination at all temperature degrees (Table 4).

Longevity test

The results of longevity tests showed that viability of recovered seeds of *P. ovate*declinedalong the period of the experiment, which was set up on June 2012 until June 2013 (Table 5). After one year, some seed packets were still containing viable seeds based on visual observations; other packets had no viable seeds but just remaining of deteriorated seeds only, especially in sandy soil pots which reflected a high degree of variability among the soil types.

Sandy soil was found to be the least type of soil to retain viable seeds, as seeds lost viability starting from the sixth month giving zero germination percent during the last six months. Irrigation regime seems to affect the viability of seeds, that seeds irrigated three times per week in sandy soil were rotten and partially or completely deteriorated, while seeds irrigated once per week were the most viable during the first six months. Thetwo centimeters depth of seed burial was the most one having viable seeds during the six months specially the second three months.

Clay and loamy soil are similar to a great extent in their ability to retain seeds viable over the time periods, as after a whole year of irrigation one per week and burial depth 2cm clay soil shows a germination percentage 91.1% and loamy soil shows 80%. Irrigation regime affects the viability of seeds in an inversely proportional way, that the more the water the less the less the viable seeds, it did not affect the viability of seeds only, but also the number of seeds remaining.

In all soil types the depth of buried seeds did not show the sharp effect on seed viability by time as that of irrigation regime, soil texture affects the viability, as the more the soil is lose and porous the less to retain seeds viable.

Soil analysis

Soil chemical properties are summarized in table 6.It wasfound that clay soil has the highest organic matter (OM), electric conductivity (EC), moisture content (MC) and total dissolved salts. However, it has the lowest pH value, while sandy soil has the highest pH value and lowest electric conductivity, moisture content and organic matter, loamy soil has a moderate values of all chemical analysis, which is in between that of sandy and clay soils.

Moisture content and moisture isotherm

Figure 1 shows the moisture isotherm of *P. sinaica* seeds after a storage period of six months. Moisture isotherms depend on the chemical composition of seeds and differ between species, between accessions of the same species and even between seeds of the same accession harvested at different stages of development. Moisture isotherms are very useful in estimating the moisture content to which seeds can be dried in a given environment.

During the six months of *Plantago* seeds storage, seed moisture content and germination rate at different relative humidity percentages were measured periodically; results are shown in tables 7 and 8. It was found that by time the germination rate was decreased even if the seed moisture content changed or not. There was a negative correlation between germination and moisture content with a correlation coefficient of - 0.622 and it was significantly as P-value was 0.006 and F-ratio 10.11 (Figure 2).

DISCUSSION

A good understanding of natural regeneration in any plant community requires information on the presence and absence of persistent soil seed banks, quantity and quality of seed production, longevity of seeds in the soil, losses of seeds to predation and deterioration, triggers for germination of seeds in the soil and sources of re-growth after disturbances [18].In the ongoing multi-prolonged efforts to halt species extinction and to promote the conservation, classification, evaluation and sustainable utilization of our rich plants heritage, this study was carried out in order to clarify and understand the ecological behavior of seeds of endemic species in their natural

habitats and its implications for conservation. Three species were considered in this study; *P. sinaica, P. ovata* and *P. lagopus*.

In terrestrial vegetation, seeds and seedlings are implicated in various ecological phenomena. In the life history of higher plants, the seedling stage is the most vulnerable and is usually accompanied by extremely high mortality, while the seed stage is uniquely resistant to various environmental stresses. Since the process of germination links these two stages showing such greatly differing risk levels, any physiological mechanism confining germination only to circumstances associated with a high probability of sound seedling establishment would have a great adaptive value [19] [20]. Seed germination is affected by a wide range of environmental factors, such as temperature, salt, water, oxygen concentration, and pH [21], [22], [23], [24], [25], [26], [13] and [27.Clear understanding of the germination response of seeds to environmental factors and agronomic aspects are useful in screening crop tolerance to stress, identifying geographical areas where a crop can germinate and establish successfully and developing management models for the prediction of timing of crop development processes. Therefore, the germination behavior of the studied species was tested.

For *Plantago* there was a great variation in the behavior of seed germination among three *Plantago* species; *P. sinaica, P. ovata* and *P. lagopus*, we observed that sulphoric acid (H_2SO_4) was the only treatment that enhanced germination in the three species at least at one of the temperature treatments. The H_2SO_4 acts by progressive corrosion of the polysaccharide mucilage layer that coat the seeds with a consequent higher permeability to air and water and thus improving the imbibitions of seeds and the normal course of the germination process [28].

It was obvious that temperature degree has a significant effect on the germination percentage of *P. sinaica* ($P \leq 0.038$), that the highest results of all treatments were obtained at room temperature (which was the highest degree), these results came to the contrary to what was reported by[29]. They stated that*Plantago* seeds can germinate over a range of temperatures (especially at low temperatures) and can reach a germination percentage more than 50%; they got results ranging from 78-92%.While [30] agreed with our results as he reported that the temperature conditions (20 to 35°C) increased the possibility of seed germination than low temperature. Supporting to our result,[31] found that *P. albicans* seeds were non-dormant and temperature significantly affected germination percentages and germination rate, as temperatures of 25°C and 25/15°C gave the highest germination percentages

Hot water and citric acid treatments significantly enhanced the germination of *P. sinaica* and *P. lagopus* but suppressed that of *P. ovata*. This is may be due to the presence of large amount of the polysaccharide mucilage content of *P. ovata,*it was observed during the study that it has more mucilage than the other two species (Rudolph-König, 2012). This mucilage was secreted during the pre-soaking treatments of hot water and citric acid in huge amounts that led to fast rotten of the seeds and hinder the germination process. On the other hand, [31]found that presence of mucilage on seeds of *P. albicans* significantly increased germination percentages at all temperatures tested. [32] study revealed that the seed mucilage of *P. minuta* plays a crucial role in regulating seed germination rates and the germination strategies adopted by controlling seed water absorption when the seeds experience different osmotic stresses or alternating wet and dry conditions.

Many studies reported a large heterogeneity and inequality for longevity between seeds originating from different plant species [10]. When seeds deteriorate during storage, they lose vigor, become more sensitive to stresses during germination and ultimately become unable to germinate. Seed aging results in reduced seedling growth[33].The rate of aging is strongly influenced by environmental and genetic factors such as storage temperature, seed moisture content and seed quality [10], [11].In order to study the viability and longevity of*Plantago* species, a year-round burial experiment was done. The seeds of *P. ovata* were buried in different soil types at three different depths. The results showed the seed viability was affected by the soil type in which it was buried in as after one year no buried seeds were viable. This may be due to the physical properties of the sandy soil as it is porous and allow water and air to reach the seeds faster; the same results was achieved by [34]. He stated that seed deterioration can be defined as the loss of quality, viability and vigor either due to aging or effect of adverse

environmental factors. [35] assumed that it may be due to rising of temperature, humidity and oxygen pressure could cause structural damages on DNA and ribosomal RNA, increasing enzyme activity, respiration and membrane permeability

It was observed that the buried seeds with water regime of irrigation once per week had high germination percentages than that of three per week; this observation was found to be in all soil types and among all soil depths. The depth of buried seeds seem to be protective to an extent as the highest germination percentages after one year (80 and 91%) were that at 2 cm depth in the loamy and clay soil respectively, which supported what [29] reported. They found that seedling emergence of *P. ovata* decreased rapidly with increased planting depth and that seeds on the soil surface had the highest emergence while no seedlings emergence was observed when placed at a depth of 3 cm and stated that emergence declined at a rate of 27% per cm of planting depth.

Hygroscopic nature of seeds allows them to maintain equilibrium moisture content with any given relative humidity of storage air, which may lead to decrease or increase in initial seed moisture content during seed storage until equilibrium has been reached. During the whole study time the moisture content and germination rate of the *Plantago* seeds were measured periodically. Decrease or increase in seed moisture in relation to relative humidity and temperature of storage air has been well documented [36], [37], [11], [35], [38], [39], [40] and [41.

This study is a pioneer one in studying the water sorption isotherm of *Plantago* species (*P. sinaica* and *P. ovata*), which was agreed with that of [42]study about the seed storage and longevity. It was found that there was no difference between the behaviors of the two species in the moisture isotherm curve, which is a very important tool for giving the information to determine the appropriate moisture content to which seeds can be dried in a given environment.

The germination rate of the*Plantago* seeds appeared to be affected by the low seed moisture content as it reaches its highest value 92% at 9.6% seed moisture, which was at 43% relative humidity and its lowest value was no germination (zero) at 18.6% seed moisture, which was obtained at 85% relative humidity. Therefore one can say that germination rate decreases with the increase in seed moisture content of the seeds and this agreed with what [38]. They found that each 1% decrease in seed moisture content may double the viability of seeds. However, viability of seeds is not only influenced by relative humidity, but also with seed temperature [43]. Rapid and uniform emergence is an important component of the definition of seed vigor. The complete loss of ability to germinate is the ultimate result of seed deterioration [38]. However, before that state is reached, various seeds in a population lose vigor at different rates. The majority of seeds come into equilibrium between their internal moisture content and the relative humidity of the atmosphere in which they are stored [44]. The results obtained in present study agreed with other studies which reported that moisture content is the most important factor effecting seed deterioration and is inversely correlated with seed viability. [45]studied in detail the moisture contents of various seeds and their atmospheric storage humidity's.

From the results obtained one can say that *Plantagosinaica* and *Plantagoovata* seeds are orthodox as it prefers low moisture and there was a negative correlation between germination and moisture content with a significant correlation coefficient (r = 0.622 and P= 0.006). Obviously, the rate of deterioration will be slow if the seeds are stored at lower relative humidity and temperature, but even so, it is almost hard to predict the accurate longevity of any particular batch of seeds when placed in storage. More moisture allows them to respire, subsequently shortening their storage life, causes spoilage through extraneous water and also by the metabolic water produced in respiration. This applies also to the great majority of seeds from dry-climate plants [44].

Table 1. Approximate composition of saturated salt solutions.

Salt	**Humidity at 25°C**	**Salt (gm)**	**Water (ml)**
Lithium Chloride	11.3	50	60
Magnesium Chloride	32.8	50	17
Potassium Carbonate	43.2	50	22
Sodium Chloride	75.3	50	15
Potassium Chloride	84.3	50	20
Sodium Hydroxide	11.1	50	35

Table 2. Germination rates of *P. sinaica*using different presoaking treatments;sulphoric acid, calcium carbonate, gibberellic acid, hot water and citric acid at three temperature degrees. Showing one way ANOVA of temperature treatments against each treatment, two way ANOVA among all the treatments and the temperature treatment and Tukey test for each treatment.

Species	Temperature	Hot Water		H_2SO_4			$CaCO_3$			G.A.			C.A		Control
		5 min	**10 min**	**0.5%**	**1%**	**1.50%**	**1%**	**2%**	**3%**	**50 mg**	**100 mg**	**200 mg**	**0.10%**	**1%**	
P.sinaica	**Room Temp.**	70.7	78.7	65.3	66.7	80.0	22.7	16.0	24.0	18.7	22.7	17.3	81.3	50.7	80.0
	25 °C	56.0	50.7	33.3	40.0	64.0	16.0	10.7	12.0	22.7	21.3	18.7	46.7	48.0	32.0
	15/20 °C	61.3	69.3	26.6	46.7	53.3	26.7	18.7	24.0	25.3	29.3	26.7	33.3	28.0	65.0
One way ANOVA	**F-ratio**	2.447	6.033	21.84	11.26	16.0	0.721	0.32	4.50	0.396	0.431	1.303	23.02	7.62	46.409
	***P* value**	0.167	0.033	0.002*	0.009*	0.004*	0.524	0.73	0.064	0.689	0.669	0.339	0.002*	0.023*	0.000*
Two way ANOVA	**F-ratio**	2.145													
	***P* value**	0.038													

* Significant values range between $P \leq 0.000$and $P \leq 0.05$.

Table 3. Germination rates of*P.ovata*using different presoaking treatments;sulphoric acid, calcium carbonate, gibberellicacid, hot water and citric acid at three temperature degrees. Showing one way ANOVA of temperature treatments against each treatment, two way ANOVA among all the treatments and the temperature treatment and Tukey test for each treatment.

Species	Temperature	Hot Water		H_2SO_4			$CaCO_3$			G.A.			C.A		Control
		5 min	**10 min**	**0.5%**	**1%**	**1.50%**	**1%**	**2%**	**3%**	**50 mg**	**100 mg**	**200 mg**	**0.10%**	**1%**	
P.sinaica	**Room Temp.**	42.4	28.0	76.0	73.3	89.3	84.0	73.3	70.7	74.7	72.0	73.3	76.0	44.0	92.0
	25 °C	45.3	08.0	92.0	80.0	96.0	80.0	69.3	73.3	82.7	80.0	81.3	68.0	78.7	84.0
	15/20 °C	13.3	18.7	84.0	81.3	96.0	80.0	70.7	72.0	70.7	73.3	67.0	70.7	73.3	66.7
One way ANOVA	**F-ratio**	57.09	8.895	4.00	1.192	3.571	1.00	0.063	0.738	0.565	0.226	0.378	0.757	20.276	40.429
	***P* value**	0.000*	0.016*	0.079	0.366	0.095	0.422	0.94	0.517	0.596	0.804	0.700	0.509	0.002*	0.000*
Two way ANOVA	**F-ratio**	2.451													
	***P* value**	0.018*													

Table 4. Germination rates of *P.lagopus*using different presoaking treatments;sulphoric acid, calcium carbonate, gibberellic acid, hot water and citric acid at three temperature degrees. Showing one way ANOVA of temperature treatments against each treatment, two way ANOVA among all the treatments and the temperature treatment and Tukey test for each treatment.

Species	Temperature	Hot Water		H_2SO_4			$CaCO_3$			G.A.			C.A		Control
		5 min	**10 min**	**0.5%**	**1%**	**1.50%**	**1%**	**2%**	**3%**	**50 mg**	**100 mg**	**200 mg**	**0.10%**	**1%**	
P.sinaica	**Room Temp.**	09.3	26.7	66.7	64.0	80.0	06.7	04.0	10.7	08.0	04.0	02.7	20.0	01.3	24.0
	25 °C	24.0	44.0	32.0	34.7	44.0	08.0	05.3	14.7	12.0	05.3	05.3	48.0	0.00	32.0
	15/20 °C	16.0	12.0	26.7	29.3	44.0	06.7	04.0	12.0	09.3	04.0	05.3	08.0	06.7	32.0
One way ANOVA	**F-ratio**	4.258	27.06	34.60	42.00	40.50	0.038	0.250	0.091	1.00	0.400	0.222	79.00	2.625	4.000
	***P* value**	0.071	0.001	0.001	0.000	0.000	0.963	0.787	0.914	0.422	0.687	0.807	0.000	0.152	0.079
Two way ANOVA	**F-ratio**	6.923													
	***P* value**	0.000*													

Table 5. Germination rate of *P.ovata* seeds buried in three different soil types; sandy, loamy and clay, with three irrigating water regimes; one time/week, two time/ week and three times/week, after fixed intervals of three months each during a period of one year (2012-2013).

Soil types	**Sandy**									**Loamy**									**Clay**								
Irrigation	**3/week**			**2/week**			**1/week**			**3/week**			**2/week**			**1/week**			**3/week**			**2/week**			**1/week**		
	Depth (cm)																										
	1	**1.5**	**2**	**1**	**1.5**	**2**	**1**	**1.5**	**2**	**2**	**1.5**	**2**	**1**	**1.5**	**2**	**1**	**1.5**	**2**	**2**	**1.5**	**2**	**1**	**1.5**	**2**	**1**	**1.5**	**2**
3 months	46.0	16.0	50.0	41.2	25.0	08.0	72.0	43.0	90.0	93.0	69.0	59.0	56.0	82.0	27.5	47.5	62.2	93.3	46.3	50.0	61.2	75.0	55.0	65.0	36.0	62.0	57.0
6 months	02.0	02.0	02.0	45.0	04.0	50.0	68.0	40.0	86.0	89.0	100	70.0	20.0	84.0	94.0	50.0	84.0	94.0	84.0	76.0	78.0	84.0	71.4	84.0	62.5	73.0	54.0
9 months	0.00	00.0	0.00	0.00	0.00	0.00	02.0	0.00	0.00	52.5	18.0	72.0	82.0	70.0	76.0	33.3	66.6	76.0	15.0	26.0	25.0	75.0	06.6	78.0	11.3	89.5	89.4
Year	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	09.5	2.10	8.00	04.0	04.3	18.0	04.0	02.2	80.0	10.0	15.0	17.0	4.44	06.8	30.0	38.6	73.3	91.1

Table 6. Soil chemical and physical properties of sandy, loamy and clay soils where*P.ovata* seeds were buried during the period of the study (2012-2013).

Soil parameters	Sandy soil	Loamy soil	Claysoil
Electric conductivity (µs)	638.0	1920	4000
pH	8.550	7.680	7.210
Moisture content (%)	0.270	2.166	4.263
Organic matter (%)	0.370	3.874	8.762
Total dissolved salts TDS (ppm)	318.0	9610	2000
Chloride (Meq/L)	2.400	9.930	13.20
Bicarbonate (Meq/L)	1.130	2.400	3.400
Magnesium (Meq/L)	3.600	7.130	15.60
Calcium (Meq/L)	3.060	11.20	32.40

Table 7. The moisture content percentage of *P.sinaica*seeds during the storage period of six months with different relative humidity percentages at 25°C temperature.

Relative Humidity(%)	**Moisture content (%)**		
	2months	**3months**	**6months**
7.5	04.60	04.56	04.90
13	05.54	05.47	07.01
32	08.53	10.58	08.80
43	09.61	09.92	10.10
75	15.67	15.83	15.70
85	19.84	18.51	18.60

Table 8. The germination percentage of *P.sinaica*seeds during the storage period of six months at different relative humidity percentages at 25°C temperature.

Relative Humidity(%)	**Germination (%)**		
	2months	**3months**	**6months**
7.5	80.0	75.0	56.6
13	90.0	80.0	66.6
32	80.0	75.0	60.0
43	92.0	87.5	46.6
75	75.0	64.0	05.7
85	60.0	22.0	0.00

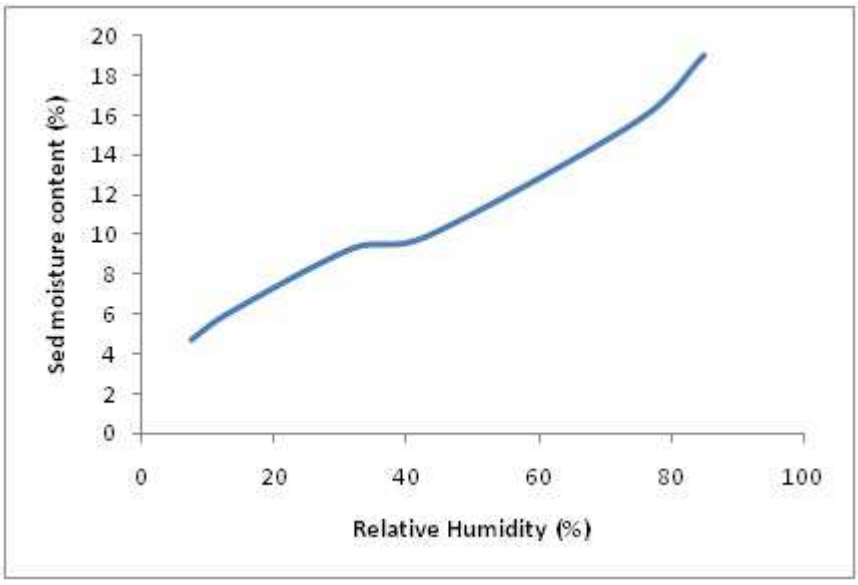

Figure 1. The moisture isotherm of *P. sinaica* seeds, showing the seed moisture content percentages at different relative humidity percentages during the period of six months storage at 25°C.

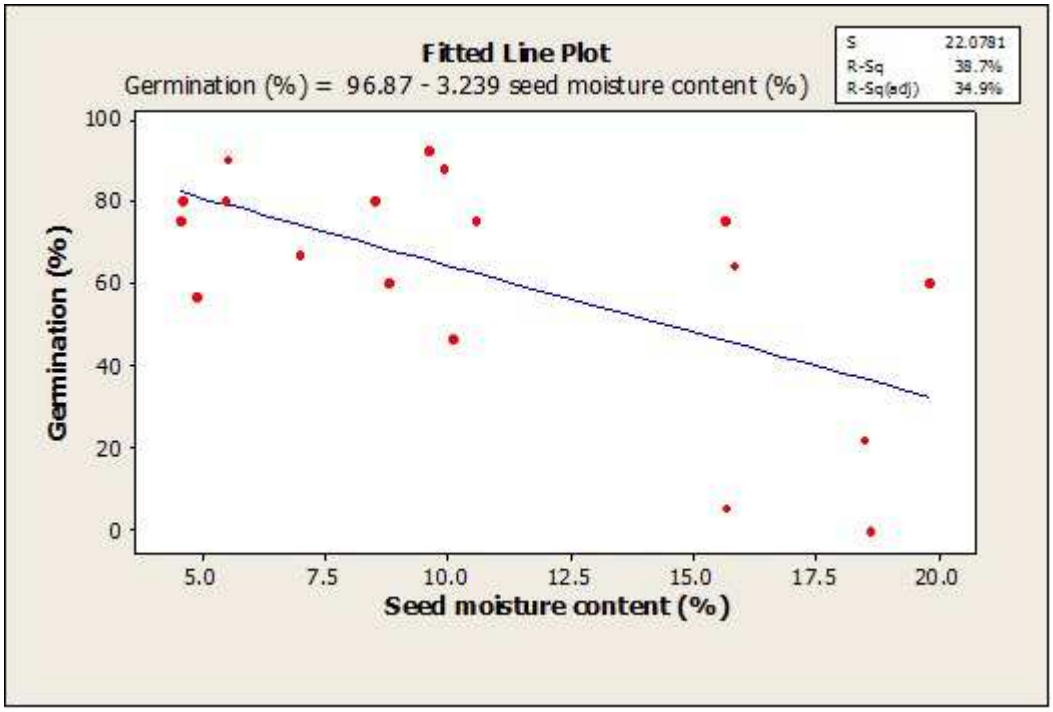

Figure 2. The regression plot between germination percentage and moisture content of *P.sinaica*seeds during the storage for six months with different saturated salt solutions, showing the regression equation.

REFERENCES

[1] Willis, J. 1980. A Dictionary of the Flowering Plants and Ferns, 8th edn. University Press, Cambridge, UK.

[2] Van der Aart, P.J. and Vulto, J.C. 1992. Biogeography and human effects. In:Kuiper PJC, Bos M. eds. Plantago: a multidisciplinary study. Berlin: Springer, 5–6.

[3] Kuiper, D. 1992. Ecophysiology of Plantago species. Phenotypic plasticity in Plantago species. In: Plantago; a multidisciplinary study., Ecol. Stud. 89, Springer-Verlag Paris.169-183.

[4] Van Delden, W., Van-Dijk, H. and Wolff, K. 1992. Genetic strategies in Plantago species. In: Plantago: a multidisciplinary study. P. J. C.

[5] Primack, R. B. 1979. Reproductive effort in annual and perennial species of Plantago. Am. Natur. 114: 51–62.

[6] Batanouny, K. H.andLamnauer, D. 2005. A Guide to Medicinal Plants in North Africa, 219-222.

[7] Dawson, J.H., and Bruns, V.F.1975. Longevity of barnyard grass, green foxtail, and yellow foxtail seeds in soil. Weed Science 23: 437-440.

[8] Froud-Williams, R. J., Chancellor, R. J. and Drennan, D. S. 1984. The influence of burial and dry-storage upon cyclic changes in dormancy, germination and response to light in seeds of various arable weeds. New Phytologist 96, 473-481.

[9] Murdoch, A.J. and Ellis, R.H. 1992. Longevity, viability and dormancy. In: Fenner, M. ed.Seeds: The Ecology of Regeneration in Plant Communities. CAB International, Wallingford, United Kingdom. Pp. 193-229

[10] Walters, C., Wheeler, L. M. and Grotenhuis, J. M. 2005. Longevity of seeds stored in a genebank: species characteristics, Seed Sci. Res. 15: 1–20.

[11] Walters, C. 1998. Understanding the mechanism and kinetics of seed aging. Seed Science Research, 8: 223-244

[12] Rajjou, L. and Debeaujon, I. 2008. Seed longevity: Survival and maintenance of high germination ability of dry seeds. C. R. Biologies 331:796–805.

[13] Mendoza-Urbina, F. A., Federico, A., Gutiérrez-Miceli, Teresa, R. Ayora-Talavera and Rincón-Rosales, R. 2012. Scarification of seeds of *Hypericumsilenoides*Juss. and its effect onGermination. Gayana Bot. 69(Número Especial): 1-6.

[14] Whigham, D. F., O'Neill, J. P., Rasmussen, H. N., Caldwell, B. A. and Mccormick, M. K.. 2006. Seed Longevity In Terrestrial Orchids – Potential For Persistent In Situ Seed Banks. Biological Conervation, 129 :24 –30.

[15] Shakeel, H., Chattha, L., Jamali A., Khalil, A. and Mangio, H.R. 2012. Effect of Different Packing Materials And Storage Conditions On The Viability Of Wheat Seed (Td-1 Variety). Sci., Tech. and Dev., 31 (1): 10-18.

[16] Jowitt, R. and Wagstaffe, P.J. 1989. The Certification of the Water Content of Microcrystalline Cellulose at 10 Water Activities. Commission of the European Communities, EUR 12429, Luxembourg

[17] Gold, K. and Hay, F. 2008. Seed Conservation Department. Equilibrating seeds to specific moisture levels, Technical Information Sheet 9. Millennium Seed Bank Project, Board of Trustees, RBG Kew, UK

[18] Teketay, D. 2005. Seed and regeneration ecology in dry Afromontane forests of Ethiopia .Tropical Ecology, 46: 29-44.

[19] Zaghloul, M. S. 1997. Ecological studies on some endemic plant species in South Sinai, Egypt. M.Sc. Thesis. Department of Botany, Faculty of Science, Suez Canal University.

[20] Moustafa, A. A., Ramadan, A. A., Zaghloul, M. S. and Helmy, M. A. 1999. Environmental factors affecting endemic species, species richness and species diversity in Saint Catherine Protectorate, South Sinai, Egypt. J. Union Arab Biol, 9(B): 419-446.

[21] Romo, J. T. and Haferkamp, M. R. 1987. Forage kochia germination response to temperature, water stress, and specific ions. Agron. J. 79: 27-30.

[22] Balbaki, R. Z., Zurayk, R. A., Blelk, M. M. and Tahouk, S. N., 1999. Germination and seedling development of drought tolerant and susceptible wheat under moisture stress. Seed. Sci. Technol. 27: 291-302

[23] Karan, S., Afria, B. and Singh, K. 1985. Seed germination and seedling growth of chickpea (Cicerarietium) under water stress. Seed. Res. 13: 1-9.

[24] Swarn, L., Singh, H., Kapia, R. and Sharma, J., 1999. Seed germination and seedling growth of soybean under different water potentials. Seed. Res. 26: 131-133.

[25] Lu, P., Sang, W. and Ma, K. 2006. Effects of environmental factors on germination and emergence of crofton weed (Eupatorium adenophorum). Weed Sci. 54: 452-457

[26] Saeidi, G., 2008. Genetic variation and heritability for germination, seed vigour and field emergence in brown and yellow-seeded genotypes of flax. Int J. Plant Prod, 2: 15-21.

[27] Esmaeili, M. M., Sattarian, A., Bonis, A. and Bouzillé, J.B. 2009. Ecology of seed dormancy and germination of CarexdivisaHuds.: Effects of stratification, temperature and salinity. Int J. Plant Prod. 3: 27-40.

[28] Muhammad, S. and Amusa, N.A. 2003. Effects of sulfuric acid and hot water treatments on seed germination of tamarind (Tamarindusindica L). African Journal Biotechnology 2: 267-279.

[29] Ghaderi-Far, F., Alimagham, S.M., Kameli, A.M. and Jamali, M., 2012. Isabgol (*Plantagoovata*Forsk) seed germination and emergence as affected by environmental factors and planting depth. International Journal of Plant Production, 6 (2): 1735-8043.

[30] Hesammi, E. 2011. Evaluation of dormancy and viability weed seeds of *Plantagolanculato.* Australian Journal of Basic and Applied Sciences, 5(9): 1715-1717.

[31] Veiga-Barbosa, L. and Pérez-García, F. 2014. Germination of mucilaginous seeds of *Plantagoalbicans*(Plantaginaceae): effects of temperature, light, pre-sowing treatments, osmotic stress and salinity. *Australian Journal of Botany* 62: 141–149.

[32] Zhang, C. P., Wu, C. X., Song, Y. C., Tian, C. Y. and Feng, G. 2014. Effects of mucilage on seed germination of the desert ephemeral plant *Plantagominuta* Pall. under osmotic stress and cycles of wet and dry conditions. Plant Species Biology, 29: 109–116. doi: 10.1111/j.1442-1984.2012.00395.x

[33] Navaey, H. N., Hezari, M. Y., Ali, S.A. and Seraji, R. A. 2014. Effects of Seed ageing on Seedling emergence of Borage (*Boragoofficinalis L.*) Medicinal Plant. International Journal of Farming and Allied Sciences, 3 (4): 353-357

[34] Kapoor, N., Arya, A., Siddiqui, M. A., Amir A. and Kumar, H. 2010. Seed deterioration in chickpea (*Cicerarietinum L.*) under accelerated aging. Asian J Plant Sci. 9(3):158-162.

[35] McDonald, M. B., 1999. Seed deterioration: physiology, repair and assessment. Seed Science Technology. 27:177–237

[36] Bewley, J. D. and Black, M. 1985. Seeds: Physiology of Development and Germination. Plenum Press, New York.

[37] Chrastill, J. 1990. Chemical and physicochemical changes of rice during storage at different temperature. Journal of Cereal Science, 11: 71-85.

[38] Copeland, L.O. and McDonald, M. B. 1999. Principles of seed science and technology. Kluwer Academic Publishers Group, Dordrecht.

[39] Rehman, Z. U., and Shah, W. H. 1999. Biochemical changes in wheat during storage at three temperatures. Plant Foods for Human Nutrition, 54: 109-117.

[40] Volenik, M., Rozman, V., Kalinović, I., Liška, A. and Šimić, B. 2006. Influence of relative humidity and temperature on changes in grain moisture in stored wheat and sunflower, Proceedings of the 9th International Working Conference on Stored Product Protection, Campinas, Brazil, 24-29.

[41] Brown, C. 2009. Agronomy Guide for Field Crops - Publication 811. Ministry of Agriculture, Food and Rural Affairs, Ontario.

[42] Bradford, K. J. 2004. Seed storage and longevity. Seed production and quality.UC Davis, Seed Biotechnology Center, USA, 76–84.

[43] Strelec, I., Komlenic, D.K., Jurkovic, V., Jurkovic, Z., UgarcicHardi, Z. 2010. Quality parameters changes in wheat varieties during storage at four different storage conditions. Agriculture Conspectus ScientificusVol 75 No. 3 pp 105-111.

[44] Alhamdan, A. M., Alsadon, A.A., Khalil, S. O., Wahb-Allah, M. A., El Nagar, M. and Ibrahim, A. A. 2011. Influence of Storage Conditions on Seed Qualityand Longevity of Four Vegetable Crops. American-Eurasian J. Agric. & Environ. Sci., 11 (3): 353-359.

[45] Ellis, R.H., Hong, T.D. and Roberts, E. H. 1989. A comparison of the low moisture content limit to the logarithmic relation between seed moisture and longevity in twelve species. Ann. Bot., 63: 601-11.