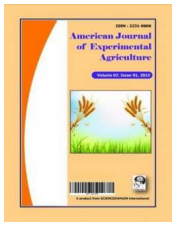

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Effects of Ambient Storage Temperature and Seed Moisture Content on Seed Longevity of Lettuce (*Lactuca sativa*)

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Authors' contributions

This work was carried out in collaboration between all authors. Author ID designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors EO, FK and MH reviewed the experimental design and all drafts of the manuscript. Authors ID, EO and KM managed the analyses of the study. Author ID identified the plants. Authors ID and EO performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

This study was conducted to test changes in seed storage longevity of lettuce seeds at ambient monthly mean temperatures mimicked in five different regions of Turkey, for 28 months and moisture contents of 7, 9 and 11±0.1%. Hermetically stored samples were removed from storage every four months and normal seed germination was tested. Survival curves were constructed and probit analyses were conducted. Differences in longevity were compared by changes in P_{50}, the time germination reduced to 50% and σ, the time germination reduced 1 probit value (i.e. 85% to 50%). The means of three moisture contents revealed that the highest (P_{50}=19.5 months) and lowest (P_{50}=5.5 months) seed longevity was obtained from Black Sea and South East regions, respectively. In all regions, shorter longevity values were recorded in seeds of high moisture

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content. Results indicated that high ambient moisture and temperature storage conditions can adversely affect lettuce seed longevity. Thus lower seed moisture content is necessary to maintain seed viability.

Keywords: Germination; seed storage; half viability period; survival curves.

1. INTRODUCTION

Post storage factors that affect seed longevity are seed moisture content, storage temperature, and oxygen [1]. As the general rule the lower the seed moisture content and temperature are the longer the seed survival. Commercial seed storages are conducted at 14-15℃ room temperatures with 40-60% of air relative humidity for medium term storage (12-36 months). Subsequently, seeds are sold and subjected to prevailing ambient temperatures at selling points (seed merchant's uncontrolled warehouse) for various months until reaching the plant producers. The prevailing ambient temperatures can be very high in some sub-tropical regions of Turkey particularly in summer months. This can be an important aspect for preserving seed quality in those regions in which temperatures are high during summer months, such as the Mediterranean and South East regions. Such high temperatures during storage may drastically reduce seed quality within a short period particularly for those sensitive species such as lettuce [2-5]. This study was conducted to evaluate how monthly ambient mean temperatures of five different regions of Turkey affect lettuce seed longevity.

Seed deaths over time show a normal distribution during storage [6,7]. This indicates that the deterioration time of the large proportion of seeds in any seed lot is similar around i.e. mid-point of normal distribution [8]. Therefore, determination of the loss of half viability period (time to germination fall to 50%), or σ, standard deviation of distribution of seed death i.e. the time to germination reduced to 1 probit value (i.e. from 85% to 50% or from 50% to 15%) would be a rational indicator of seed longevity of any seed lot [6,7] Longevity of lettuce seeds stored at ambient monthly mean temperatures in five different regions were compared by P_{50}, and σ values in this work.

2. MATERIALS AND METHODS

Cultivar of Yedikule of lettuce (*Lactuca sativa* L.) was obtained from commercial seed company. Seed moisture content was determined according to ISTA [9]. Initial seed moisture content (mc) was 6.8%. Seed moisture contents were arranged to 7, 9 and 11±0.1% by humidifying over 100% relative humidity. Appropriate seed moisture content was arranged by weighing seeds frequently until weight was stabilized. Final seed moisture content (mc) of the lots was calculated from the initial seed weight and moisture by the following formula:

Seed weight at desired mc = (100-initial mc)/ (100-desired mc) x weight of seed

Then, 35 samples of 200 seeds were prepared in hermetic aluminum foil packets. For five groups that were stored in incubators mimicking the monthly mean temperatures of the Central Anatolia, the Black Sea, the Marmara, the Aegean-Mediterranean, and the South East regions for 28 months. Monthly mean storage temperatures are presented in Table 1 for each region. These temperatures represent the monthly means over 35 years in each region. Samples were taken every four months over 28 months, 7 samples for each region and 35 (5 region x 7 samples) samples. Seeds (4 replications of 50 seeds) were germinated at 20℃ for 7 days [9]. Normal seedling percentage was counted when germination test period was over. The survival curves in every species in each region were analyzed by probit analysis [8]. Then, P_{50}, time to viability reduced to 50%, and σ, 1 probit germination time i.e. germination fall from 85% to 50% were calculated for each region by regression equations. Statistical analysis was done by SPSS.

3. RESULTS

The survival curves of lettuce seeds stored at ambient temperature in five regions and three percentages of seed moisture content storage over 28 months were presented in Fig. 1. Seed viability remains high in longer period in seeds having lower moisture contents. As seed moisture increases the survival gets shorter (Table 1). The half viability period, P_{50} and σ values in all five regions reduced by the increased seed moisture contents. The highest

P_{50} values were observed in 7% in all regions and the lowest at 11% seed moisture. The longest survival as indicated by mean P_{50} (mean of the three seed m.c) was observed in storage in Black Sea as 18.5 months and the shortest survival was seen in South East as 8.1 months (Table 2). σ values were also shown in the same trend to change from 11.4 months in Black Sea to 5.5 months in South East. Survival of lettuce seeds at ambient storage in Black Sea region had more than doubled survival as compared to South East.

Table 1. Changes in monthly mean storage temperatures (℃) arranged by values of 35 years in five different regions of Turkey. Seeds are hermetically packaged at the appropriate moisture content and stored in the incubators at mentioned temperature over 28 months. Samples were tested in every 4 months (April, August and December)

	Month											
	1	2	3	**4***	5	6	7	**8**	9	10	11	**12**
	13	14	15	**16**	17	18	19	**20**	21	22	23	**24**
	25	26	27	**28**								
Region	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
B. Sea	5	7	8	13	17	22	24	24	20	15	10	7
Marmara	1	3	5	10	15	19	23	23	17	12	6	2
C. Anat.	3	5	7	12	16	20	23	23	18	13	8	5
Eag-Med	9	11	13	16	21	25	28	28	25	21	14	11
S. East	5	6	10	15	21	28	31	31	26	19	10	6

***: Bolds are sampling months*

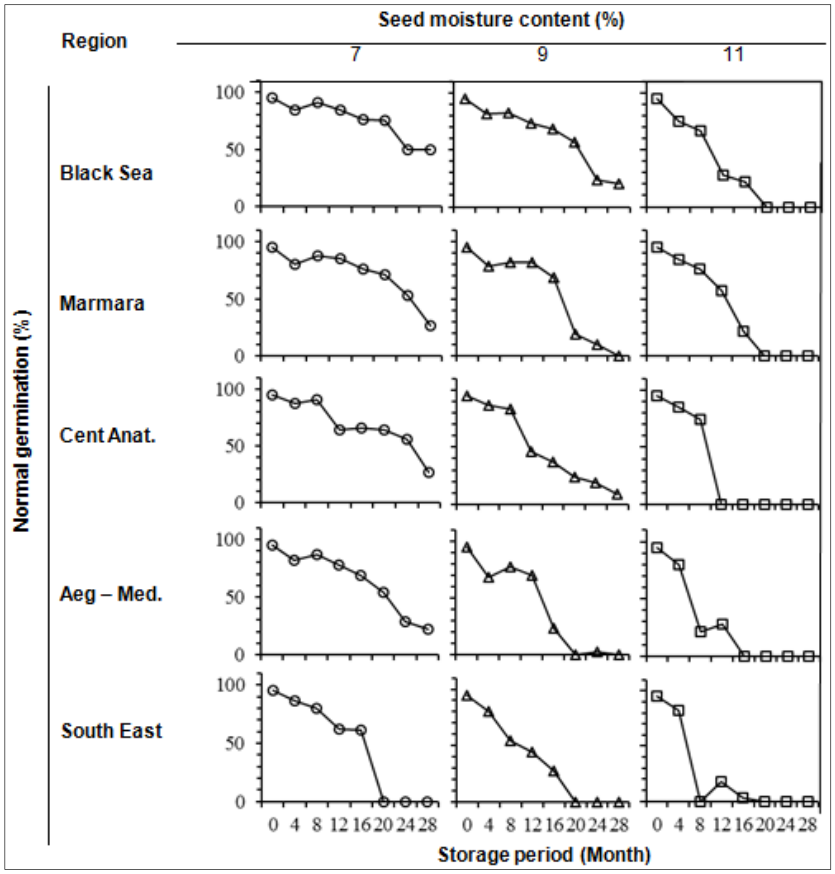

Fig. 1. Seed survival curves of lettuce seeds stored at ambient temperatures of five regions of Turkey in relation to 3 different seed moisture contents over 28 months

Table 2. Regional monthly ambient storage temperatures affected seed longevity (P_{50}, σ) in lettuce in relation to changes in seed moisture contents. Seeds were stored over 28 months in hermetic packets with 7, 9 and 11±0.1 seed m.c and sampled in every four months

Region	Seed m.c. (%)	Longevity (Month)	
		P_{50}	σ
Black Sea	7	27.9	17.2
	9	18.9	11.7
	11	8.8	5.3
	Mean	**18.5**	**11.4**
Marmara	7	24.2	14.9
	9	13.7	6.7
	11	9.9	5.0
	Mean	**15.9**	**8.8**
Central Anatolia	7	22.4	13.7
	9	14.5	9.2
	11	6.3	5.1
	Mean	**14.4**	**9.3**
Eag-Med.	7	19.6	11.8
	9	10.1	5.7
	11	6.5	5.4
	Mean	**12.0**	**7.6**
South East	7	10.8	5.1
	9	9.1	5.3
	11	4.4	6.2
	Mean	**8.1**	**5.5**

4. DISCUSSION

The results of the present study indicated that lettuce seeds had shorter longevity when stored at high temperature means of months in the South East region of Turkey, compared to those of the other regions. Regional storage differences are important to preserve longevity when the storage is performed under ambient temperatures. Maintaining seed quality in tropical and sub-tropical regions are problematic [10] due to the high temperature and relative humidity. The Aegean-Mediterranean and South East regions are sub-tropical climates, particularly in the summer seasons in which, high temperature and relative humidity prevail (Table 1). Such high temperatures are extremely damaging seed longevity when combined with high relative humidity [4,5,7] which is seen survival curves in lettuce seeds stored in South East and Eagan-Mediterranean regions with 11% seed moisture content (Fig. 1). Seeds can be stored in medium term storage of 10-15℃ and seed moisture content of 5-7%, for small-seeded crops such as lettuce [11,12]. However, at selling points in the market, ambient air temperature storage is unavoidable. Even though seeds are hermetically packet (seed moisture is low) they are not usually stored under optimum temperatures due to the lack of available storage cold room. This is also the case for seed merchants and farmers in undeveloped regions. Running expense of cold room is high and not affordable for farmers.

5. CONCLUSION

As a conclusion, cold seed storage is preferable, but when uncontrolled ambient storage is necessarily practiced in different regions, seeds should be stored at low seed moisture contents of approximately 7% and storage no longer than 4-6 months at a maximum in order to keep viability for commercially acceptable level.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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