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Effects of Temperature, Light and Storage on Seed Germination of *Ulmus glabra* Huds. and *U. laevis* Pall

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Abstract: The effects of temperature, light and storage on the germination of *Ulmus glabra* and *Ulmus laevis* seeds were studied. Germination tests were carried out under constant temperatures of 20°C and alternating temperatures of 30/20°C. Temperature significantly affected seed germination of *U. glabra* not stored, and seed germination was the highest at 30/20°C under dark or light. Temperature and light (0 or 8 h) did not significantly affect germination of *U. laevis* seeds not stored. When seeds were stored for 2 years, seed germination of *U. glabra* and *U. laevis* was significantly affected by temperature and light (0, 8, 16 and 24 h). Two years storage of *U. glabra* seeds increased light demands for germination percentage, and the seeds could be stored at 4°C for 2 years without losing its viabilities when germinated at 30/20°C under light. Although germination percentage and germination rate of *U. laevis* seeds reduced after 2 years of storage, germination parameters were still quite high when seeds were germinated at 30/20°C under light.

Key words: Elm, germination, seed storage, photoperiod

INTRODUCTION

Ulmus glabra Huds. and *Ulmus laevis* Pall. are the native species to Turkey (Davis, 1982; Anoin and Ozkan, 1993). Little is known on population dynamics, seed biology and seedling production of these species although elms are valuable for their hard, tough wood, and they have been planted for environmental purposes. Habitat destruction and the bark beetles, which are the vectors of the Dutch Elm Disease fungal agent, have caused enormous damage to elm populations, and continues to pose a major threat to the genetic diversity of the species in Turkey and in Europe (Anoin and Ozkan, 1993; Collin, 2002).

Elms regenerate through seeds, which are characterized by the lack of any dormancy, and seeds of most elm species require no pre-sowing treatment. Under natural conditions, elm seeds that ripen in the spring usually germinate in the same growing season and seeds ripening in the fall germinate in the following spring (Brinkman, 1974). Although germination performance usually remains constant over a wide range of temperatures, and germination tests of most elm species may be made at alternating temperatures of 30/20°C (Brinkman, 1974; Thompson, 1970), temperature and light requirements vary among elm species (Brinkman, 1974; ISTA, 1985; Phartyal *et al*., 2002; Çiçek and Tilki, 2007). Also, elm seeds keep best if stored at low moisture content in sealed containers at 0-10°C, but storage temperature, seed moisture and species can affect viable period of the elm seeds (Brinkman, 1974). Thus, the aim of this study was to determine the effect of storage, light and temperature on the germination of *U. glabra* and *U. laevis* seeds.

MATERIALS AND METHODS

Mature samaras of *Ulmus laevis* (40°52' N, 30°36' E, 30 m asl) and *Ulmus glabra* (40°46' N, 31°25' E, 800 m asl) were collected from western Black Sea Region of Turkey in May 2003. They were cleaned and upgrading by separating empty seeds from the empty ones (Phartyal *et al*., 2002), and seeds were germinated. Germination tests were carried out under constant temperature of 20°C and alternating temperature of 30/20°C. Within each temperature regime, seeds were germinated under 0 and 8 h photoperiod with 1000 lux. Seeds were also stored in hermetically sealed containers at 4°C for two years, and then seeds germinated at 20 and 30/20°C under four light regimes of 0, 8, 16 and 24 h. Seed moisture content was determined on two samples of 5 g each that were oven dried for 17 h at 103°C and seed moisture content was 8.7% (fresh weight). A total of 400 seeds, 4 replicates of 100 seeds, each were used in all treatments for *U. laevis* and *U. glabra* seed germination.

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The seeds were put in petri dishes of 20 cm diameters on a moist filter paper and the petri dishes were put in germination chambers. Seeds were monitored every day and moistened periodically. The appearance of a 5 mm radicle long was the criterion for germination. Germinated seeds were counted every day until the 14th day (ISTA, 1985).

Germination Percentage (GP) at the 14th day was calculated for each species. Germination rate was also measured and expressed as Peak Value (PV), an index of germination speed which is calculated as the quotient of the highest value of the cumulative germination percentage, divided by the number of days from the beginning of the test (Czabator, 1962). For each trial, germination percentage data were arcsine transformed. Mean values were subjected to analysis of variance, and the means were separated according to Duncan's Multiple Range Test ($p<0.05$).

RESULTS AND DISCUSSION

Germination Percentage was significantly affected by temperature (20 or 30/20°C) in control (not stored) and 2-year stored *U. glabra* seeds (Table 1). In control seeds 8-h light did not significantly affect germination percentage, and germination percentage was the highest at 30/20°C under light or dark (GP>90%), but 8 h light significantly affected germination percentage after 2 years of storage. Germination percentage was the highest at 30/20°C under 8 h light in 2-year stored seeds (GP=87.2%). Germination rate of *U. glabra* seeds was also significantly affected by temperature and was the highest at 30/20°C in both control and 2-year stored seeds (Table 2). Germination rate at 30/20°C was not significantly affected by light in control and stored seeds, and also germination rate was not significantly reduced at 30/20°C by seed storing.

Temperature (20 and 30/20°C) and light (0 and 8 h) did not significantly affect germination percentage of *U. laevis* seeds (control) as found by Çiçek and Tilki (2007) but temperature affected germination percentage in 2-year stored seeds (Table 1). Germination percentage was the highest at 30/20°C under light or dark in stored seeds (GP>87%). Germination percentage of stored seeds was significantly reduced at all temperatures and light conditions compared to control. Germination rate was the highest at 30/20°C under dark in control seeds and the highest at 30/20°C under 8 h light in stored seeds (Table 2). Germination rate was significantly reduced at all germination conditions by storing seeds for 2 years.

When 2-year stored seeds were germinated at 20 and 30/20°C under four light conditions (0, 8, 16 and 24 h), germination percentage and germination rate were significantly affected by temperature and light in *U. glabra*, and germination percentage was affected by temperature only in *U. laevis* seeds (Tables 3 and 4). The temperature of 30/20°C produced the highest germination percentage and germination rate in *U. glabra* and *U. laevis* when averaged for four light regimes.

Light (0, 8, 16 and 24 h) significantly increased germination percentage in *U. glabra* seeds and 24 h light produced the highest germination percentage (Table 3). Germination rate at 30/20°C was the lowest under 16 h light (Table 4). Both germination percentage and germination rate were the highest at 30/20 °C under 24 h light.

Light (0, 8, 16 and 24 h) did not significantly affect germination percentages at 30/20°C in *U. laevis* but affected germination rates (Table 3 and 4). Although 24 h light at 20°C produced the highest germination percentage, germination rate was low compared to that of 30/20°C (Table 4). The highest germination rate was found at 30/20°C under 8 h light.

According to Brinkman (1974) and ISTA (1985), 20 or 30/20°C under 12 hours photoperiod is optimal for germination of some elm species (*Ulmus americana, U. parviflora, U. pumila, U. rubra, U. laevis*). Phartyal *et al.* (2003) found that 24-26°C is the optimal temperature for

Table 1: Germination percentages (GP) of *Ulmus glabra* and *U. laevis* seeds under two temperature and light regimes, stored for 0 (control) and 2 years

Species	Temperature	Light	Control	2-year storage
U. glabra	20	8 h light	86.1Bab	82.9Aa
	20	dark	82.0Aa	79.1Aa
	30/20	8 h light	91.5Ab	87.2Ab
	30/20	dark	91.2Bb	82.5Aa
U. laevis	20	8 h light	93.7Ba	81.4Aa
	20	dark	93.7Ba	79.3Aa
	30/20	8 h light	96.4Ba	89.0Ab
	30/20	dark	98.5Ba	87.8Ab

Means followed by the same capital initial in the row are not significantly different at $p<0.05$. Means within each species followed by the same initial(s) in the same column are not significantly different at $p<0.05$

Table 2: Germination rates (PV) of *Ulmus glabra* and *U. laevis* seeds under two temperature and light regimes, stored for 0 (control) and 2 years

Species	Temperature (°C)	Light (h)	Control	2-year storage
U. glabra	20	8 h light	7.4Aa	8.1Bb
	20	dark	6.5Aa	6.5Aa
	30/20	8 h light	9.5Ab	9.1Ac
	30/20	dark	9.0Ab	9.2Ac
U. laevis	20	8 h light	10.2Bb	7.2Aa
	20	dark	8.0Ba	6.8Aa
	30/20	8 h light	13.5Bc	11.2Ac
	30/20	dark	15.2Bd	9.2Ab

Means followed by the same capital initial(s) in the row are not significantly different at $p<0.05$. Means within each species followed by the same initial in the same column are not significantly different at $p<0.05$

Table 3: Germination percentages (GP) under two temperatures and four light regimes for two *Ulmus* species, stored for two years

Species	Temperature (°C)	Light (h) 0	8	16	24	Average
U. glabra	20	79.1a	82.9a	87.1b	81.3a	82.5A
	30/20	82.5a	87.1ab	87.2ab	90.3b	86.8B
U. laevis	20	79.3a	81.4a	81.4a	90.0b	83.0A
	30/20	87.8a	89.0a	89.4a	88.8a	88.7B

Means followed by the same letter in the row are not significantly different (p<0.05). Means within each species followed by the same capital initial in the column are not significantly different (p<0.05)

Table 4: Germination rates (PV) under two temperatures and four light regimes for two *Ulmus* species stored for two years

Species	Temperature (°C)	Light (h) 0	8	16	24	Average
U. glabra	20	6.6a	8.1b	8.4b	9.3c	8.1A
	30/20	9.2b	9.0b	8.1a	9.4b	9.0B
U. laevis	20	6.8a	7.2a	7.2a	7.7b	7.2A
	30/20	9.2a	11.1b	9.9ab	10.4ab	10.1B

Means followed by the same initial(s) in the row are not significantly different at p<0.05. Means within each species followed by the same capital initial in the column are not significantly different at p<0.05

seed germination of *Ulmus wallichiana* depending on the seed lots, and germination temperature of 25°C produced more germination percentage compared to that of 10, 20 30 and 35°C in *U. americana* seeds (Staub, 1967). Besides temperature, light also affects seed germination of some elm species (Lupe, 1956; McDermott, 1973). Rohmeder (1942) found the highest germination percentages in *U. glabra* seed at 25 and 30/20°C under light, but Çiçek and Tilki (2007) stated that light did not affect germination percentage of *U. glabra* seeds. This study demonstrated that storage affected seed germination response to temperature and light in *U. glabra* and *U. laevis*.

According to Brinkman (1974) *Ulmus glabra* seeds can be kept for 6 months at 0-10°C and *U. laevis* for 6 months at room condition. *Ulmus alata* and *U. crassifolia* can be also stored for 1 year at 8°C. The present study revealed that *U. glabra* seed could be stored at 4°C for 2 years without losing its viabilities when germinated at 30/20°C. When *U. glabra* seeds were stored for 2 years, their light demands for germination percentage were increased, and the highest germination percentage and germination rate were found at 30/20°C under 24 h light. Although germination percentage and germination rate of *U. laevis* seed reduced after 2 years of storage, germination parameters were still quite high when seeds were germinated at 30/20°C. When *U. laevis* seeds were stored for 2 years, their light demands for germination rate were increased and germination rate was higher under light after seed storage.

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